

MONTHLY NOTICES  
OF THE  
ROYAL ASTRONOMICAL SOCIETY.

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VOL. XXXVI.

November 12, 1875.

No. I.

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PROF. J. C. ADAMS, F.R.S., President, in the Chair.

John Brise Colgrove, Esq., M.A., Rossall School, Fleetwood,  
was balloted for and duly elected a Fellow of the Society.

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*The University Observatory at Oxford.* By the  
Rev. Prof. Pritchard.

It may be in the recollection of the Society that, exactly two years ago, I had the gratification of announcing the munificent intention of the University of Oxford to build and maintain an Observatory for researches connected with Astronomical Physics, and for the promotion of the study of the various branches of practical and philosophical astronomy among the members of the University. I have now the still further pleasure of communicating to the Society the completion of the undertaking in all its details.

With one exception, no great alteration has been made in the proposed construction of the building as detailed in the communication printed in the *Monthly Notices* of December 1873.

The exception referred to consists in the arrangements of the shutters in the revolving domes. The difficulties involved in the successful construction of such shutters is only too well known to astronomers, whether professional or amateur. It was publicly stated at a recent meeting of the Institute of British Architects by one of the most eminent and experienced

of its members, and I believe the dictum had already been generally received among ourselves, that the astronomical necessity of an Observatory, and the æsthetic requirements of architecture, are incompatible; it was also added that ornamental crestings on the top of the revolving roofs were impossibilities. Happily the impossible problem has been solved at Oxford; and to Mr. Charles Barry must be assigned the honour, be it great or little, of having harmonised the claims of architecture with the necessities of practical astronomy.

The very ingenious attempt made by the Engineer (not the Architect) of the Oxford Observatory domes, to construct a flexible shutter of corrugated steel capable of being rolled up into a box, on experience failed entirely. Had this able engineer been spared to his profession, he would probably have succeeded on a further trial; but as it was, the difficult task of devising some practicable substitute devolved upon the Director of the Observatory. The problem was to devise a form of shutter which should be practically applicable to a revolving dome of handsome form, and that form neither hemispherical nor cylindrical.

After some consideration the solution of this problem turned out to be, as usual, something unexpectedly simple. The idea which suggested itself was to divide the shutters into three portions, *bending* them to the form of the dome (made approximately cylindrical at the opening or slip), and then sliding them up and down and over each other in their respective grooves, like the overlapping lights of a large greenhouse. The shutters, it was hoped, would be heavy enough to descend by their own weight, and each, or all of them together, could be drawn up into any required portion of the slit, and there maintained by ordinary sash-lines, winches, and lazy-pullies. This plan has been executed with perfect success; the system of shutters moves easily, causes no trouble, has proved perfectly watertight during the recent deluge of rains, and affords the means of excellent ventilation. The annexed Plate (reduced from an enlarged photograph now presented to the Society) of Mr. Charles Barry's design, will enable the members to form their own judgment as to the compatibility of elegant form with the necessities of an astronomical revolving roof.\*

I now gladly turn to subjects of greater scientific interest, and probably more nearly touching the sympathy of the Royal Astronomical Society. Mr. Grubb's large equatoreal refractor proves, on experience, to be a very admirably constructed instrument. A photograph thereof shall be submitted to the judgment of

\* It should be understood that in the present instance, there were especial reasons for studying external appearance, on account of the beauty of the Park in which the University allowed the Observatory to be erected. A revolving roof of the usual form, either of a hemisphere or of a drum, would have been regarded as an intolerable disfigurement of the place.

the Society at its next meeting. The object-glass is  $12\frac{1}{4}$  inches clear aperture, and about 176 inches focal length: its optical qualities have been pronounced excellent by several competent judges who have examined its performance. The mounting of this large telescope has excited our admiration and our gratitude as often as we have had occasion to use it; its motion is steady and easy, and, when clamped, it is firm.

The contrivances for illuminating the divisions of the declination circle (of 30 inches diameter) and the field of view, the latter with either dark or bright wires, are ingenious and successful. The gas jet suspended from the extremity of the perforated declination circle, performs all this necessary work: it effectively illuminates also the position circle of nine inches diameter, which is permanently attached to the observing end of the telescope; alterations of intensity of light and colour are within the easy command of the observer.

The declination circle is read at the observing end by means of two long microscopes furnished with micrometer eye-pieces; while a third and contiguous long microscope, with a wide field as a rough reader, allows an easy method of setting the instrument in north polar distance. In the first instance, the flexure of the long microscope tubes (probably an inherent concomitant of such contrivance) proved an intolerable annoyance; but the defect has been effectually remedied by the attachment of a small platinum plate engraved with a fiducial line, which rotates with the tube of the telescope, closely to the plane of the divisions of the circle. Guided by our own experience, we can safely recommend this method in the future construction of very large instruments.

The clamping of the instrument in both elements is effectually made by means of a probably novel, and certainly very ingenious arrangement, of cylindrical male and female V-pieces, which are brought into contact by a small rod close to the observer's hand.

The driving clock does its work probably as well as any other existing clock; it is, comparatively, excellent, but not faultless. I am informed that Mr. Grubb has discovered a remedy of the defects by means of electrical connection with the normal clock of the Observatory, and that the experiment is now being made at Dr. Huggins's Observatory at Tulse Hill. If it there succeeds, we shall hope to adopt it at Oxford.

The contrivances for moving the telescope through small arcs while attached to the driving-clock, and for changing the rate for observations of the Moon, are perfectly satisfactory.

There are two subsidiary telescopes, of four inches, and two and a quarter inches, aperture respectively, attached to the tube. These we regard by no means in the light of mere finders, but each of them has its own illuminating apparatus, and each is adapted to all the micrometers and eye-pieces of the larger tube. The finder proper, when such aid happens to be required, consists of

a pair of rifle-sights applied to the tube of the four-inch telescope.

There are three micrometers: two of them are filar micrometers, and the third is a double image micrometer by Troughton and Simms, and forms one out of the many generous gifts of Dr. De La Rue.

Finally, the instrument, independently of its many eye-pieces, whether solar or otherwise, is furnished with a Star spectroscope of unusual excellence by Mr. Grubb; a second, by Mr. Browning, is the gift of Dr. De La Rue; while the complement is completed by a Sun spectroscope admitting of the dispersion of either four prisms of sixty degrees, or of eight, or of twelve, at the desire of the observer. This latter powerful but simple instrument, by Grubb, I hope to submit to the inspection of the Society at its next meeting.

The devising and construction of an efficient observing chair always occasions some trouble and anxiety. I have myself adopted the simple idea of a set of five steps, some forty-two inches wide, terminating with a rather broad platform and rails at the top: the whole moves on large castors, and can be pushed into any required position with the finger. Various cushions and hassocks lie on the steps of this machine, in order to vary by slight degrees the height of the observers as they sit to their work: I say observers, because it is sometimes of advantage, and to us often so, for two observers to work simultaneously on the same phenomenon with two telescopes of different apertures.

The refracting telescope, with its appendages thus described, occupies the larger or western dome. The eastern, or De La Rue dome, contains that gentleman's munificent gift to the University, and we can only hope it may be destined to effect some work worthy of its former reputation. Both these domes rotate on a simple adaptation of Smeaton's line ring. A child may easily turn either of them.

The annex between the two domes is divided into two portions: they contain one of Dr. De La Rue's large reflectors mounted as an altazimuth, with a small motion near the meridian, a five-foot transit instrument, and three smaller instruments mounted on their stone pedestals, and intended for educational purposes among the members of the University.

The rooms under the two dome rooms already described are devoted to a computing room, a private room for the Director, and a photographic room together with its dark chamber. A somewhat lofty basement underlies all these rooms, and the whole building is lighted with gas. In one of the compartments of the basement there are placed Dr. De La Rue's polishing machine for telescope mirrors, and Foucault's apparatus for testing their figures.

I need scarcely repeat that the Observatory and its instruments are not designed so much for meridional observations as for re-

searches connected with what may properly be termed Astronomical Physics.

Nevertheless, we are at all times prepared to devote the large apertures of the instruments to any desirable purposes to which they appear adapted: and although the Observatory has only been finally completed in all its details within the last few days, a considerable set of observations of six of the satellites of Saturn have been taken, which we trust will prove of some value, and will shortly be communicated to the Society.

In concluding the description of these really noble specimens of astronomical engineering, I cannot refrain from recording my admiration of the admirable manner in which Mr. Grubb has much more than merely fulfilled his contract with the University of Oxford. It has been one among many other happy results of the removal of ancient fiscal misarrangements, that English opticians have at length overtaken their eminent brother artists on the Continent. It is not now so much to Munich that it is necessary to resort for our largest and most perfect instruments; but gigantic observatories and colossal telescopes are at this moment in course of construction in the workshops of Dublin, intended to promote astronomical research in some of the chief cities of Continental Europe.

I may also, I trust, be pardoned for repeating a remark which I believe I have made in this Society before, to the effect that the artists and constructors of these admirable astronomical machines—admirable alike for their ponderous stability, for the smoothness of their motion, and for their adaptation to the most minute delicacy of accurate measurements—claim at our hands a meed of gratitude and honour scarcely if at all less than that which we so gladly accord to the illustrious astronomers who so successfully avail themselves of the mechanician's skill. And all honour be also paid to the enlightened munificence of the University of Oxford, who, notwithstanding their comparatively limited pecuniary resources, and the vast and ever-increasing variety of claims that are made upon them, have devoted so much encouragement and so considerable a sum to the cultivation of the science which so deeply engages our own sympathies. Dr. De La Rue also may be congratulated on the hitherto successful arrangements to which his own generosity gave the first impulse.

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*On the Preparations which are being made on the Continent for promoting Physico-Astronomical Observations.* By Warren de La Rue, D.C.L., F.R.S.

It is scarcely necessary for me to tell the Fellows of the Royal Astronomical Society that their favourite branch of our science, namely, the Physics of Astronomy, is now engaging the earnest attention of foreign professional astronomers to a greater extent than obtained only a few years ago, and that grand preparations

are now being made at several continental State-Observatories to grapple with the important truths which can only be revealed by adequate instrumental appliances such, indeed, as are far beyond the reach of most private fortunes. It was a matter of satisfaction to me to learn that photographic Observatories are to be included in at least two of those Observatories, namely, in Paris and Vienna.

I was particularly impressed with the new Observatory in course of erection in the vicinity of Vienna, and I have thought that an account of it might have some interest for the Royal Astronomical Society; hence I have ventured on making this short communication respecting it.

The old Observatory is situated nearly in the centre of Vienna, in the midst of narrow bustling streets, closely overlooking house-tops and chimnies, and, consequently, quite unfitted for accurate astronomical work. It was founded in the year 1753, its first Director being M. P. M. Hell; it was rebuilt on the same ill-adapted site in the years 1826-27, under the direction of M. T. T. von Littrow, the father of the present Director, and was adapted and equipped by him to meet as far as possible the requirements of a modern Observatory; but even at that period the surrounding buildings must have greatly militated against satisfactory astronomical work.

The present Director, M. C. von Littrow, repeatedly urged upon the Austrian Government the desirability of removing the National Observatory to a more favourable position, and ultimately, in 1873, obtained the sanction of the Minister of Public Instruction (K. von Stremayer) for the building of an Observatory adapted in every respect to the present state of astronomical science.

Before deciding on the plan and equipment of the new Observatory, the Austrian Government wisely adopted the suggestion of M. von Littrow, and sent Prof. E. Weiss, First Assistant of the Observatory, to visit the public and private Observatories of England and America, and the workshops of the instrument-makers in these and continental countries.

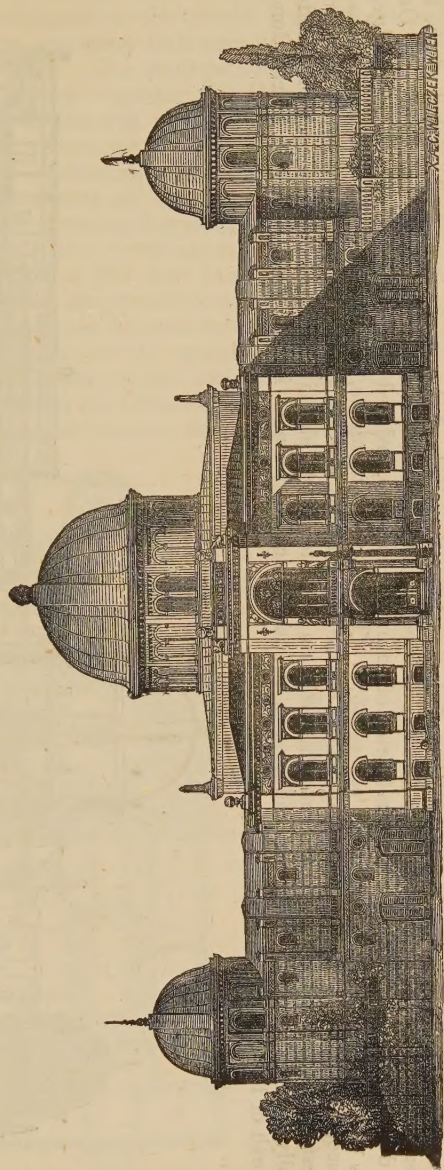
From information thus gathered it was determined to ask the Government for a refractor of about 26 inches aperture as the principal instrument of the new Observatory; this necessitated a dome of 42 feet internal diameter, and formed the starting-point in the consideration of the general plan of the Observatory, which has been ably worked out by the architect, M. F. Fillner, under M. von Littrow's direction.

The site of the new Observatory is admirably chosen three miles to the north of the centre of the city: it consists of a plateau of between 14 and 15 acres, at an elevation of about 200 feet above the mean level of Vienna. The new Observatory is 330 feet long in the direction of north-south, and 240 feet in that of east-west. The foundation stone was laid in June 1874, and it is hoped that the building will be completed in 1877. Judging from the great progress which had been made when

I visited it in October, I believe that it will be ready to receive the instruments at that time. The buildings comprise the dwelling of the Director and apartments for the assistant astronomers. Although the personal comfort of the astronomers will be greatly promoted by residence within the walls of the Observatory, it would have been, in my opinion, preferable for the dwellings to have been detached, as the heated air emanating from them will be liable to disturb the definition of the instruments.

Fig. 1 represents the south front of the Observatory, the central entrance opening into the dwelling of the Director, which is to the south of the large dome—not, perhaps, the best position that could have been selected.

FIG. 1.



The large Equatoreal which is to occupy the central dome has been ordered of Mr. Howard Grubb, of Dublin, who has also been intrusted with the construction of the revolving dome intended to cover it, as well as that of the three smaller domes, two of which are situated east and west of the central dome, and are shown in figure 1. One of these domes will contain an equatoreal refractor of 12 inches aperture, ordered of Mr. Alvan Clark, of Cambridgeport, Mass., which will be finished about the end of 1876. These two instruments, together with a meridian circle having a telescope of 8 inches aperture, and augmented by the instruments already in the old Observatory, will constitute the first equipment of the new establishment. Later on it is intended to place in the third dome an equatoreal reflector specially adapted for photography, and also a prime vertical instrument in the room near the fourth dome, to the north of the central dome.

FIG. 2.

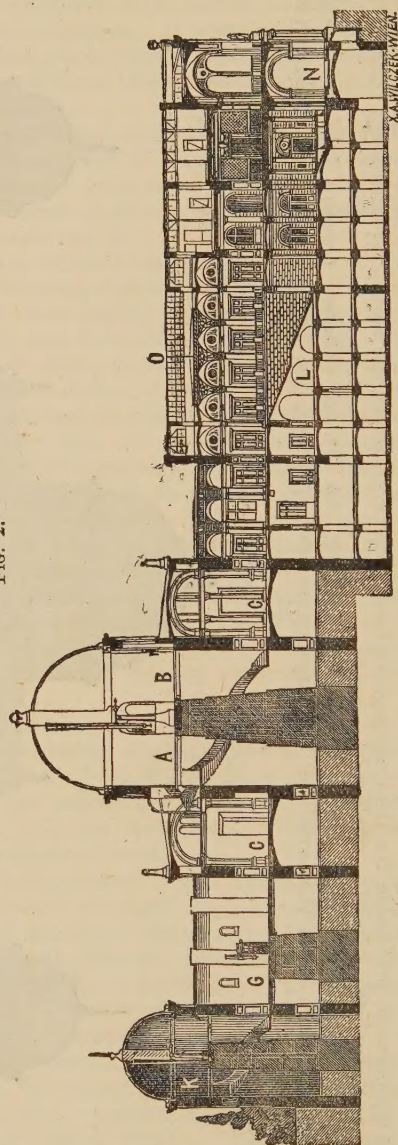


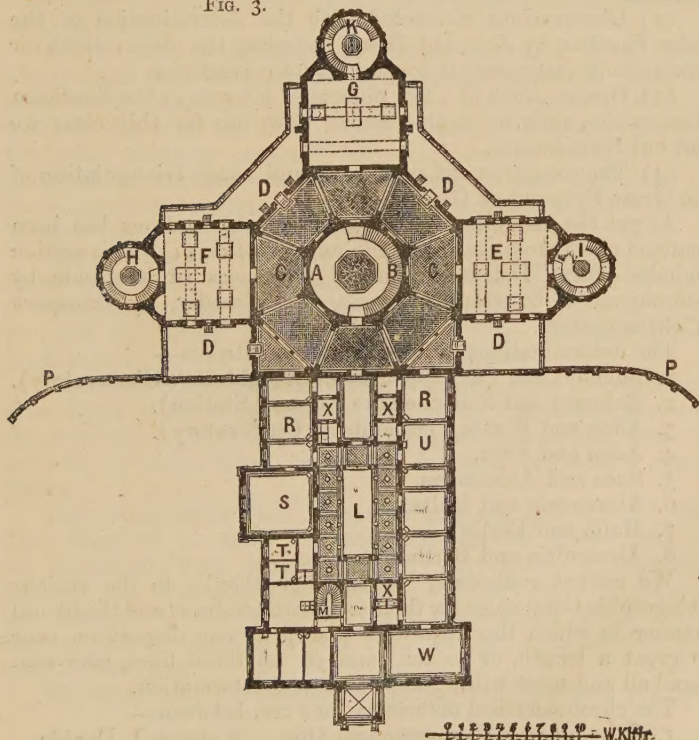
Figure 2, drawn on a smaller scale than Fig. 1, shows the general arrangement of the establishment in plan.

A B is the great dome, 42 feet in diameter; this dome is surrounded at its lower portion by the central hall C C, which

will contain all the portable instruments. From this central hall access is obtained to the terraces D, adapted for observations with portable instruments or the naked eye. The rooms E and F will receive the meridian instruments, and in G is to be placed the prime vertical. The smaller domes, H, I, and K are each 25 feet in diameter: besides the instruments before spoken of, one of these domes will most probably be equipped with an altazimuth or a heliometer. The 12-inch Alvan Clark is to be used mainly and continuously for the determination of the position of the small planets and comets.

The connection of the dwelling-house with the Observatory is best shown in the section Fig. 3, which is on the same scale as Fig. 1. It will be seen that the first floor of the Director's house is on the same level as the ground floor of the Observatory; the apartments of the assistant Astronomers are on the ground floor. CC show the section of the gallery surrounding the ground floor of the great dome; L the section of the staircase. Referring again to Fig 2, W is the Director's house in plan; S and T T the library; U the lecture theatre; and lastly, R the offices.

FIG. 3.



From the preceding description it will be seen that Austria

will not be left behind in the steps which are being taken to promote Physico-Astronomical observations; and I sincerely hope that our own Government will ere long adopt measures to ensure to England a fair chance of honourably competing in the advancement of that branch of Astronomical Science which the Fellows of this Society have done so much to promote mainly from their own individual resources.

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*On the State of the Reductions of their Observations of the Transit of Venus.* By Lord Lindsay and Mr. Gill.

The observations accumulated during the Expedition are:

(1) Those connected with the geographical position of the station, Belmont, and the connection of that with neighbouring stations.

(2) Observations connected with the determination of the Solar Parallax by *Juno* and *Venus*, including the observations for ascertaining instrumental constants and corrections.

(3) Observations of a few objects of interest in the Southern Hemisphere, such as double stars; however, for this class we had but little leisure.

(4) The measurement of a base, and exact triangulation of the Great Pyramid of Gizeh.

As yet the reduction of this mass of observations has been confined chiefly to those that come under section (1). This section includes—First. Determinations of differences of longitude by interchange of telegraphic signals, and secondly, by transport of chronometers.

The determinations by telegraph are, between—

1. Belmont and Pamplémousse (Mr. Meldrum's Observatory).
2. Belmont and Solitude (the German Station).
3. Aden and Bombay (Chambers' Observatory).
4. Aden and Suez.
5. Suez and Alexandria.
6. Alexandria and Malta.
7. Malta and Berlin; and
8. Alexandria and Berlin direct.

We cannot sufficiently express our thanks to the various Telegraphic Companies for their excessive kindness and the liberal manner in which the lines were placed at our disposition over so great a length, or to the *employés* on those lines, who rendered all and most willing assistance and information.

The chronometrical determinations are, between—

- |                                  |          |                |
|----------------------------------|----------|----------------|
| 1. Belmont and Pamplémousse Obs. | 8 chron. | } Double runs. |
| 2. Belmont and Solitude . . .    | 36 „     |                |

3. Belmont and Mr. Neate's station in Rodrigues, 2 double runs.\*

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|------------------------------------|--------------------------------------|
| 4. Belmont and Reunion . . . 1 run | } making Aden,<br>Mauritius, 2 runs. |
| 5. Reunion and Seychelles. . . 1 " |                                      |
| 6. Seychelles and Aden . . . 1 "   |                                      |
| 7. Mauritius and Aden . . . 1 "    |                                      |

8. Aden and Suez, 2 runs, from 3 to 8, consisting of runs of 80 chronometers.

9. In Egypt. Mr. Gill's station, and Mr. Hunter's station, at Suez, 1 double run of 8 chronometers.

10. Helroan (Dr. Döllen's station) and Great Pyramid,

1 double run of 9 chronometers, and

1 " " " 18 "

11. Suez to Greenwich, 2 runs, 50 chronometers.

12. Greenwich to Liverpool (Bidston Observatory) 2 runs, 50 chronometers.

During these runs the chronometers were compared *inter se* twice a day.

Where the stations have been well connected by telegraphic Exchanges the chronometer runs will be chiefly used as a control on their rates.

In all these determinations, almost the whole of the time observations have been reduced in duplicate; and from many of these being made in the vertical of a circumpolar (Döllen's method) the work has been one of considerable labour, though the great accuracy obtained fully compensates for this. The telegraphical exchanges are also reduced, so that the results of the telegraphic longitudes are nearly complete; in these interchanges nearly 10,000 signals have been sent.

The 50 chronometers employed were tested for nine weeks (some longer) at the Liverpool Observatory, one week at each of the following temperatures: 85°, 70°, 55°, 70°, 85°, 70°, 55°, 70°, and 85°, before the expedition, and after the return, one week each at 55°, 70°, 85°, 95°, 85°, 70°, and 55°.

An investigation has been made from the data furnished by these trials on the temperature co-efficients; and tables, showing the correction (Thermal) for every degree Fahrenheit, between 55° and 95°, have been constructed for each instrument separately.

This investigation has been one of great labour, and has been extended to many chronometers besides those used in the expedition, from data supplied by Mr. Hartnup, from the trials at the Liverpool Observatory; one peculiarly interesting and instructive case being that of a chronometer whose daily rate in various temperatures has been recorded without interruption for ten years.

We hope that the results of these investigations, coupled

\* By a "double run" is meant the chronometers being sent and returning forthwith to the same place.

with much information collected by the makers, will help to extend the knowledge of the chronometer, its errors, and their causes.

The temperature has been found from day to day during the expedition by means of an uncompensated chronometer, whose rate is affected about 6 sec. a day for  $1^{\circ}$  Fahr., and the application of these corrections is now being proceeded with.

The observations for latitude with the altazimuth, and with the transit instrument, in the prime vertical, are reduced.

The reduction of the observations on *Juno*, with the heliometer, is delayed until the meridian observations of the stars of comparison are completed, till the zone of stars observed for absolute value of the scale, and temperature co-efficient, has been remeasured, and till the extension of the division errors up to  $2^{\circ}$  distance is finished, as well as a redetermination of the errors of the screw of the reading microscope.

All these determinations are being pushed on as rapidly as possible. The reduction of the *Venus* heliometer measures is also delayed for the same purpose.

A redetermination of the screw of Airy's D.I. micrometer, used on *Venus* by Dr. Copeland, will be concluded before the reduction of those observations.

The instrument for measuring the photographs of the Transit is now almost complete, and the investigation of the errors of its scales and microscopes will be undertaken as soon as it is erected.

The photographs have been found to bear a magnifying power of 10 diameters well; and some will bear 20 with advantage.

*Dun Echt, 1875, Nov. 12.*

*On the Error of the Tabular Place of Venus during the Transit of December 8, 1874. By Colonel Tennant, R.E.*

(From a Letter to E. Dunkin, Esq., Honorary Secretary.)

I have been waiting till I should have something definite to say about the error of the place of *Venus* during the Transit, though I have long seen that there must be some mistake in Mr. Hind's estimate of the accuracy of M. Le Verrier's Tables. I have now completed the reduction of the altazimuth observations with the following result :

$$\begin{aligned} \text{Correction to (R.A. } \odot) - (\text{R.A. } \odot) &= +4''\cdot47 - 0''\cdot071 \, dL - 0\cdot989 \, d\pi \\ \text{,, (N.P.D. } \odot) - (\text{N.P.D. } \odot) &= +2''\cdot24 - 0''\cdot017 \, dL - 2\cdot629 \, d\pi \end{aligned}$$

The longitude has been assumed as  $5^{\text{h}} 11^{\text{m}} 31^{\text{s}}\cdot00$  E. which turns out to be exactly what Mr. Pogson makes from signals we

have interchanged; but, of course, the longitude of Madras must be determined by telegraph, and then there will be some correction, and I may vary the amount by a few hundredths of a second of time from small corrections which have not been included by Mr. Pogson.

If the terms for longitude and solar parallax (which, by-the-by, has been assumed as  $8''.93$ ,  $\log.=0.95085$ ) be left out, then the probable error of the R.A. is  $\pm 0''.312$ , and of N.P.D.  $\pm 0''.443$ .

*Roorkee, October 14, 1875.*

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*On an Old Drawing of the Sun. Translation from a Letter from Signor Capello, Director of the Observatory at Lisbon, to Dr. De La Rue.*

I take the liberty of sending you a photographic copy of an allegorical plate representing the Sun, by Sheiner and Kircher, published at Rome in 1635.

I do not know to what work the plate belongs. I have not met with it in the *Rosa Ursina*, nor in the other works of Sheiner or Kircher.

Looking at this plate, one would be tempted to believe that the observers in question were already acquainted with the Protuberances and the Photosphere.

The clouds or fumarols all round the solar disk may very well represent the Protuberances, and the series of little tongues of fire may also very well represent the Photosphere. At any rate, it is an extraordinary coincidence, for both of them are quite recent discoveries.

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*Drawings of Mars and Jupiter, made with the 26-inch Equatoreal of the United States Naval Observatory.\**

*(Communicated by Rear-Admiral C. H. Davis, U.S. N. Supt.)*

## I.

These drawings were made with coloured chalk crayons on ordinary crayon paper in the following way. A circle three inches in diameter was first drawn in lead pencil on a small piece of the crayon paper, and this was secured to a small board, which was convenient to hold in the hand. The Washington mean time of beginning the drawing was (usually) noted to the

\* The drawings are preserved, and may be inspected in the Library of the Society.—Ed.

nearest minute, and the drawing was begun by sketching in the most prominent lines, the details of the central parts being next filled in, and those of the extreme zones last. The time of the ending of the drawing was then noted, and a careful comparison of the completed drawings made with nature, and a few alterations made. The actual features of the drawing usually correspond to the mean of the times of beginning and ending. No account was taken of the elliptic form of the disk, as the drawings were regarded peculiarly as studies of the central parts of the disk, both as to forms and colours, though quite as much pains was taken with the extreme portions. The work was done with the full aperture, 26 inches, and usually with a positive eye-piece magnifying 400 diameters. The other and more important work of the telescope forbade the removal of the filar micrometer, and the insertion of a glass plate ruled into squares, as was originally proposed, so that the positions of the bands, &c., are merely careful eye estimates. Particular attention was paid to studies of the colours of the disk; and although the drawings are quite unsatisfactory in this respect, owing to the want of skill of the observer, and the difficulty of obtaining proper crayons, it has been attempted to supplement the drawing by verbal descriptions. Standards of colour have been sought for; one of the most satisfactory has been indicated by Prof. Cleveland Abbe, of the United States Signal Service. The horizon is frequently surrounded on the hot summer days, in the middle portions of the United States, with piles of cumulus clouds, among which (in the recesses near the bases, and occasionally on the surfaces), may be found a reddish or salmon colour, which is quite similar in tint and intensity to the normal colour of *Jupiter's* main belt during 1875. It has been noticed with some surprise that the same reddish salmon colour is the prevailing tint of *Mars*, except that this red is more glaring and strong. After many trials it was found that the best results for colour were obtained by using the *same* crayon for drawings of both *Mars* and *Jupiter*. Owing to the low altitude of *Mars*, drawings of this planet were soon abandoned, in spite of his otherwise favourable position.

## II.

### *Description of the Photographs.*

By a misapprehension the photographer has photographed not only the drawing, but a narrow space about it. In all cases the pencil border of the drawing shows in the photograph, and is the true limit. Any marks beyond this are simply portions of the crayon dust rubbed over this line in the process of drawing, except in the case of the egress of satellites, &c., which cases can be easily distinguished. The photographs show *only* the forms; the relative blackness of the various pictures is not at all kept in the different photographs.

## III.

*Detailed Descriptions of the Drawings of Mars.*

Drawing No. 1. 1875, June 14. Observer, Holden.  $11^h 15^m$  to  $30^m$ ; bad seeing; 400 magnifying power. I see no polar white; sketch made with power of 175; image very poor; sketch finished  $11^h 38^m$ . The border around the reddish and black parts should be a yellowish red. Some of the details put in with power 400.

Drawing No. 2. 1875, June 16. Observer, Holden. Begun  $10^h 40^m$ , finished  $11^h 15^m$ ; magnifying power 400. Slight indications of polar snow, especially at south pole. The whole southern hemisphere unsatisfactorily drawn. It is full of delicate detail, hard to represent.

Drawing No. 3. 1875, June 21. Observer, Holden. Mere sketch finished  $10^h 45^m$ ; magnifying power 400. *Mars* so low that it is very unsteady. I have noticed several times small *white* projections from the limb near the south pole. They are so unsteady that I cannot draw them. I should call them *round*, and brilliant white.

Drawing No. 4. 1875, June 23 (2 drawings). Observer, Holden. Magnifying power 400 (1st); from  $10^h 15^m$  to  $10^h 37^m$ . Seeing bad at first, but suddenly becomes better. First drawing left unfinished and No. 2 begun. Second drawing begun  $10^h 20^m$ , finished  $11^h 7^m$ . Seeing much better than any other drawing of *Mars* this year.

Drawing No. 5. 1875, August 5. Observer, Holden. Magnifying power 400; begun  $8^h 20^m$ , ended  $8^h 47^m$ . Whole drawing unsatisfactory, but a few things certain. South pole quite white, north pole somewhat so. A small projection near south pole, at or about *a*; forms on the disk not well caught. Red colour satisfactory; none of the rest quite so. From *a* to *b* a long bright yellow edge to the disk; that is, inside the border.

## IV.

*Detailed Description of the Drawings of Jupiter.*

Drawing No. 1. 1875, June 9. Observer, Holden. Magnifying power 400. Imperfect sketch, finished  $9^h 30^m$ .

Drawing No. 2. 1875, June 10. Observer, Holden. 2 imperfect sketches: No. 1.  $8^h 20^m$  to  $8^h 35^m$ ; No. 2.  $8^h 35^m$  to  $8^h 46^m$ .

Drawing No. 3. 1875, June 16. Observer, Holden. Magnifying power 400; drawing finished at about  $9^h 55^m$ . Seeing not good, but image fairly seen at times.

Drawing No. 4. 1875, June 18. Observer, Holden. Magnifying power 400; begun  $7^h 55^m$ , finished  $8^h 22^m$ . The atmo-

sphere is hazy, but image steady. The whole planet has a yellow tinge from the haze, which is not kept in the drawing. The red is too red, and the slate colour too bright and too marked; but the cloud forms are well kept.

Drawing No. 5. 1875, June 21. Observer, Holden. Magnifying power 400; 8<sup>h</sup> 0<sup>m</sup> to 8<sup>h</sup> 40<sup>m</sup>. Seeing very fine. The space A B C is too large; that is, the rest of the drawing is crowded, but most of the forms are kept. The central band is of a rose

pink, banded in the strands  like a rope and

covered with a thin veil of white cloud, whose prevailing shapes are mountain like . The whole

drawing is unsatisfactory, but still quite faithful.

Drawing No. 6. 1875, June 23. Observer, Holden. Magnifying power, 400. 8<sup>h</sup> 3<sup>m</sup> to 8<sup>h</sup> 27<sup>m</sup>. Seeing good for first ten minutes, and then grows rapidly worse; drawing not wholly finished. The worst fault in this picture is that the outlines of the parts bordering on the *main* red belt (which is to-night entirely in the north hemisphere) are a little too *prononcés*.

Drawing No. 7. 1875, June 54. \* Observer, Holden. Magnifying power, 400. Begun 8<sup>h</sup> 15<sup>m</sup>; ended 8<sup>h</sup> 55<sup>m</sup>, *aa'* and *bb'* too far apart. Seeing not first rate. The columnar structure uniting *aa'* and *bb'* is too coarse; these little pillars are bright shining points. General Note on all. Colour of central band in all drawings of *Jupiter*. Try to get it a cross between rose pink and salmon colour.

Drawing No. 8. 1875, July 8. Observer, Holden. Magnifying power, 400. 8<sup>h</sup> 15<sup>m</sup> to 8<sup>h</sup> 50<sup>m</sup>. Tint of *Jupiter* a pale yellowish-white. Tint of bands rosy pink with a dash of salmon colour; the pink of central band looks as if seen through a gauzy white cloud.

Drawing No. 9. 1875, July 13. Observer, Holden. Magnifying power, 400. Emersion of Satellite, I. 16<sup>h</sup> 6<sup>m</sup> 10<sup>s</sup> to 30<sup>s</sup>? by clock. Clock correction = + 16<sup>s</sup>. Drawing begun at 8<sup>h</sup> 40<sup>m</sup>, ended at 8<sup>h</sup> 57<sup>m</sup>. Seeing very poor and planet yellow. The position of the shadow of the satellite is that for 8<sup>h</sup> 40<sup>m</sup>. Whole drawing very unsatisfactory. The general aspect of the planet is not caught, and seeing is too bad to be quite sure of the individual forms. That of the oblique cloud preceding the satellite's shadow is fairly well drawn.

Drawing No. 10. 1875, July 14. Observer, Holden. Magnifying power (probably) 400. Begun at 8<sup>h</sup> 0<sup>m</sup>; ended at 8<sup>h</sup> 27<sup>m</sup>, on account of cloud. Drawing is not completed. The southern quarter is almost an olive green; the northern quarter approaches this tint.

Drawing No. 11. 1875, July 16. Observer, Holden. Magnifying power, 400. Begun 8<sup>h</sup> 32<sup>m</sup>; ended 8<sup>h</sup> 48<sup>m</sup>. Very unsteady. Planet yellow; general appearance of forms between *aa'* and *bb'* like those of June 21 or June 24.

*Catalogue of Points on the Moon's Surface whose position has been recently determined by Micrometrical Measures.* By E. Neison.

Those who have devoted attention to astronomical questions in connection with the Moon have long recognised the necessity of the completion of the system of measured points on the lunar surface. In especial, for the adequate mapping of the lunar surface, it is essential that the present mere skeleton of a system of measured points should be properly filled in by the determination from micrometrical measures of the position of a requisite number of new points.

Lohrmann was the first to attempt to form such a system, and from 150 good measures he ascertained the position of 21 points, though five of these, resting on fewer than five measures, were merely approximations.

It is however to Mädler that the real commencement of this work must be ascribed, as Lohrmann's results were too partial to be regarded as being properly such. From 784 measures\* Mädler determined the places of 85 new points on the lunar surface, besides increasing the accuracy of seven of Lohrmann's places by additional measures, numbering in all 31. By uniting Lohrmann's measures with his own, Mädler obtained a series of 105 points whose places had been determined with some accuracy, and resting mainly on from eight to eleven measures.

Since 1832, however, nothing further has been done with a view of completing this work, though this has always been recognised as desirable. It is true Mädler subsequently made a few measures to determine the place of the north pole of the Moon, and Bessel and Wichmann ascertained the place of Mösting A: these were made, however for different and special purposes.

In its present condition, the system of measured points on the lunar surface is entirely inadequate; and, with the exception of Manilius and Mösting A, the places of the points have not been determined with sufficient accuracy for several important purposes. But though Bessel, Encke, and Mädler have urged the desirability of obtaining additional determinations, and the British Association appealed for further results, no attempt until now appears to have been made to complete the work left by Mädler in 1832.

As the subject appeared pressing, and (selenographically at least) of the highest importance, in 1873 it was determined to undertake as far as possible the extension of the present series of measured points. For this purpose, during 1874 and 1875,

\* Mädler made 919 measures, but 104 were subsequently rejected as discordant, or for other reasons.

numerous measures were obtained whenever possible, employing a modified method, and using a somewhat more convenient system of reduction than Mädler's. This method was framed with a view of admitting of the introduction, at any subsequent time, of a correction for the effects of any real libration.

On the basis of these measures the following Catalogue has been founded, and rests on the results of 340 sets of measures, each consisting of five separate results. The Catalogue consists of the name of the point, the longitude and latitude found, and the number of measures these are based on. The designation of Beer and Mädler for the same, together with the place previously assigned to the point, are also added, as well as the name of the authority for this place. In the column giving the class of measures, 1st stands for points of the First Order, and 2nd for points of the Second Order, using Mädler's classification. The first are measured from the limb by the method of Encke, and the latter from one of these last, by a measure with a position micrometer. These latter are of course in a very marked degree inferior in point of accuracy to the first. In the column of authorities, L stands for Lohrmann, M for Mädler, and W for Wichmann.

The Catalogue comprises 35 points in all, and includes four whose places had previously been determined with some accuracy by Lohrmann, and four others whose position had been fixed still more satisfactorily by Mädler. Those eight points enable a comparison to be made between these new measures and those of Lohrmann and Mädler. The remaining points have been selected mainly for the purpose of fixing accurately the position of the lunar equator and first meridian, or else to fill the most important gap in the system of Beer and Mädler, or, finally, for some analogous special point, mainly directed with a view to the requirements of a new investigation into the real libration of the Moon.

The series taken in unison with the results given by Mädler in the *Der Mond*, establish with a very considerable accuracy the position of the points—Gassendi, Kepler, Landsberg, Bode, Lalande, Murchison A., and Hipparchus C. Taken together with the results obtained by Nicollet for Manilius and Wichmann for Mösting A., they will enable the exact position of the lunar equator and selenographical first meridian to be ascertained with some precision.

*Catalogue of Points on the Surface of the Moon, whose Positions have been Determined from Micrometrical Measures, during 1874-1875.*

| Name             | No.<br>of<br>Observations. | Position from Recent Measures. |             | Beer and Mädler's<br>Designation. | Class<br>of<br>Measures. | No.<br>of<br>Measures. | Position from Previous Measures. |             | Authority. |
|------------------|----------------------------|--------------------------------|-------------|-----------------------------------|--------------------------|------------------------|----------------------------------|-------------|------------|
|                  |                            | Longitude.                     | Latitude.   |                                   |                          |                        | Longitude.                       | Latitude.   |            |
|                  |                            | ° ' "                          | ° ' "       |                                   |                          |                        | ° ' "                            | ° ' "       |            |
| Agrippa          | 3                          | 10 4 17 W.                     | 3 55 20 N.  | Agrippa                           | 1st                      | 9                      | 10 22 13 W.                      | 4 4 16 N.   | L.         |
| (a) Archimedes A | 17                         | 7 10 47 E.                     | 27 44 58 N. | Archimedes A                      | 2nd                      | 1                      | 6 31 E.                          | 27 56 N.    | M.         |
| (b) Bessarion    | 11                         | 37 0 41 E.                     | 14 58 48 N. | Bessarion ?                       | 2nd                      | 1                      | 37 5 E.                          | 14 37 N.    | M.         |
| Bessel           | 7                          | 17 22 26 W.                    | 21 54 14 N. | Bessel                            | 2nd                      | 1                      | 17 37 W.                         | 21 43 N.    | M.         |
| Bode             | 28                         | 2 39 21 E.                     | 6 37 55 N.  | Bode                              | 1st                      | 6                      | 2 30 48 E.                       | 6 37 54 N.  | L.         |
| Bode A           | 6                          | 1 19 40 E.                     | 8 53 57 N.  | Bode A                            | 2nd                      | 1                      | 1 16 E.                          | 8 56 N.     | M.         |
| Bode B           | 6                          | 3 9 41 E.                      | 8 42 20 N.  | Bode B                            | 2nd                      | 1                      | 3 0 E.                           | 8 23 N.     | M.         |
| Bohenberger A    | 4                          | 39 24 10 W.                    | 17 3 8 S.   | Bohenberger a                     |                          | Estimated              | 39 10 W.                         | 17 4 S.     | M.         |
| Brayley          | 5                          | 36 25 10 E.                    | 20 53 52 N. | Euler A                           | 2nd                      | 1                      | 36 36 E.                         | 20 46 N.    | M.         |
| Encke            | 7                          | 36 35 35 E.                    | 4 18 14 N.  | Encke                             |                          | Estimated              | 36 40 E.                         | 3 40 N.     | M.         |
| Encke B          | 8                          | 36 18 56 E.                    | 1 57 6 N.   | Encke b                           |                          | Estimated              | 36 20 E.                         | 1 30 N.     | M.         |
| Eratosthenes     | 7                          | 11 41 19 E.                    | 14 23 58 N. | Eratosthenes                      | 1st                      | 6                      | 11 26 22 E.                      | 14 26 35 N. | L.         |
| (c) Gassendi     | 10                         | 39 30 6 E.                     | 17 0 48 S.  | Gassendi A                        | 1st                      | 9                      | 39 31 37 E.                      | 16 55 40 S. | M.         |
| Guerike C        | 8                          | 11 43 37 E.                    | 11 48 53 S. | Guerike C                         | 2nd                      | 1                      | 11 39 E.                         | 11 13 S.    | M.         |

| Name.          | No.<br>of<br>Observations. | Position from Recent Measures. |                    | Beer and Mädler's<br>Designation. | Class<br>of<br>Measures. | No.<br>of<br>Measures. | Position from Previous Measures. |                    | Authority. |
|----------------|----------------------------|--------------------------------|--------------------|-----------------------------------|--------------------------|------------------------|----------------------------------|--------------------|------------|
|                |                            | Longitude.<br>° ' "            | Latitude.<br>° ' " |                                   |                          |                        | Longitude.<br>° ' "              | Latitude.<br>° ' " |            |
| Hipparchus C   | 18                         | 8 3 34 W.                      | 7 22 27 S.         | Hipparchus c                      | 2nd                      | 1                      | 8 18 W.                          | 7 19 S.            | M.         |
| (d) Hortensius | 12                         | 27 41 8 E.                     | 6 2 8 N.           | Hortensius                        | 2nd                      | 1                      | 27 52 E.                         | 6 56 N.            | M.         |
| (e) Kepler     | 14                         | 37 38 58 E.                    | 7 57 48 N.         | Kepler                            | 1st                      | 11                     | 37 42 18 E.                      | 7 46 13 N.         | M.         |
| Lalande        | 17                         | 8 47 41 E.                     | 4 26 34 S.         | Lalande                           | 1st                      | 6                      | 8 44 23 E.                       | 4 20 3 S.          | L.         |
| Landsberg      | 9                          | 26 18 49 E.                    | 0 25 28 S.         | Landsberg                         | 1st                      | 10                     | 26 33 49 E.                      | 0 29 51 S.         | M.         |
| Landsberg A    | 8                          | 31 5 26 E.                     | 0 2 20 N.          | Landsberg A                       | 2nd                      | 1                      | 30 43 E.                         | 0 5 S.             | M.         |
| Mädler         | 5                          | 29 11 58 W.                    | 10 55 59 S.        | Theophilus A                      | 2nd                      | 1                      | 29 34 W.                         | 10 58 S.           | M.         |
| Marius         | 2                          | 49 57 5 E.                     | 11 58 44 N.        | Marius                            | 2nd                      | 1                      | 50 27 E.                         | 11 27 N.           | M.         |
| Menelaus       | 11                         | 15 31 2 W.                     | 16 24 17 N.        | Menelaus                          | 2nd                      | 1                      | 15 46 W.                         | 16 13 N.           | M.         |
| Milichius      | 11                         | 29 40 1 E.                     | 10 0 15 N.         | Milichius                         | 2nd                      | 1                      | 29 57 E.                         | 10 20 N.           | M.         |
| Mösting        | 6                          | 5 53 2 E.                      | 0 36 26 S.         | Mösting                           | 2nd                      | 1                      | 5 54 E.                          | 0 38 S.            | M.         |
| Mösting A      | 24                         | 5 13 56 E.                     | 3 10 25 S.         | Mösting A                         | 1st                      | 50                     | 5 13 23 E.                       | 3 10 55 S.         | W.         |
| Murchison A    | 18                         | 1 0 4 W.                       | 4 3 57 N.          | Triesnecker A                     | 2nd                      | 1                      | 1 6 W.                           | 3 57 N.            | M.         |
| Proclus        | 6                          | 46 28 24 W.                    | 16 12 8 N.         | Proclus                           | 1st                      | 9                      | 46 31 34 W.                      | 16 9 8 N.          | M.         |
| Ptolemaus A    | 10                         | 0 58 22 E.                     | 8 34 58 S.         | Ptolemaus A                       | 2nd                      | 1                      | 0 44 E.                          | 8 56 S.            | M.         |
| Reinhold       | 10                         | 22 37 26 E.                    | 3 13 19 N.         | Reinhold                          | 2nd                      | 1                      | 22 36 E.                         | 3 4 N.             | M.         |
| (f) Rosse      | 8                          | 34 19 38 W.                    | 17 48 37 S.        | Pracastorus E                     | 2nd                      | 1                      | 33 41 W.                         | 17 27 S.           | M.         |
| Ukert          | 11                         | 1 9 10 W.                      | 7 48 24 N.         | Ukert                             | 2nd                      | 1                      | 1 26 W.                          | 7 33 N.            | M.         |
| Wichmann       | 4                          | 37 56 13 E.                    | 7 41 15 S.         | Euclides a                        |                          | Estimated              | 37 35 E.                         | 7 50 S.            | M.         |

With regard to these results, the following Notes seem desirable :

a. (Archimedes A.) There is a very considerable discrepancy between the place of this crater as given by Mädler and as found by these later measures ; and this difference appears to be too large to be due merely to errors incidental to the process adopted by Mädler in making his measures of the 2nd order. In the *Der Mond* the symbol for the point measured is not given, but in the map the crater A alone answers to the description, though it is placed in only  $6^{\circ} 22'$  E longitude, the latitude being the same. Mädler's place appears to be, however, undoubtedly wrong. From measures that have been made it would appear, in fact, that not only is the crater A placed too near Archimedes, but that this last great walled plain is too far west.

The measures on which the position of this point rest were made in two separate series, divided by a period of four months, and are :

1st Archimedes A. 8 measures.  $7^{\circ} 7' 52''$  E. Long.  $27^{\circ} 46' 48''$  W. Lat.

2nd Archimedes A. 9 measures.  $7^{\circ} 13' 23''$  E. Long.  $27^{\circ} 42' 53''$  W. Lat.

These results are therefore very fairly accordant, though some of the separate results exhibit peculiar differences, analogous to similar features presented in some of Mädler's series.

b. (Bessarion.) Some uncertainty attaches to the identity of this point. Mädler describes Bessarion in the *Der Mond* as a  $6^{\circ}$  bright crater, with, on its north, a light spot containing a small brighter crater in  $37^{\circ} 5'$  E longitude and  $14^{\circ} 37'$  N latitude, and his map agrees with this description. On the Moon, however, Bessarion under high illumination appears to occupy the centre of an elliptical bright spot, and the centre of this spot has been measured. No favourable opportunity has yet occurred to enable the exact relation of this elliptical white spot to the ringplain Bessarion to be ascertained.

c. (Gassendi.) The glittering  $7^{\circ}$  bright point towards the centre of Gassendi, measured by Mädler, was considered by him to be a point about five miles north of the principal centre peak, and not to be a central elevation. This does not appear to be exact, and this  $7^{\circ}$  bright point seems to be undoubtedly the most northern central peak. It is this last that has now been measured, and no bright point exists immediately north of it.

d. (Hortensius.) The place assigned by Mädler to this formation appears to be certainly nearly a degree too far north, and to be due to an error in reducing the observation that was made. None of the measures on which its position now rests gave a latitude within some half a degree of that assigned by Mädler. The point measured was the centre of the glittering spot that appears to occupy the site of Hortensius in high illuminations. According to Mädler this occupies the exact site of the crater, and this is certainly correct, for four additional measures taken

of the centre of the crater when close to the terminator give the following position :

Hortensius      4 measures       $27^{\circ} 45' 22''$  E. Long.       $6^{\circ} 0' 46''$  N. Lat.

e. (Kepler). The considerable discrepancy between the two places, though both of the first order, admits of an easy explanation. Of the eleven measures on which the position assigned by Mädler rests, three were made during the very commencement of the work ; and many of the results obtained by Mädler during this period he had to reject as faulty. Now these three measures, though retained by Mädler, are discordant when compared with the other eight, as they place the latitude nearly three-quarters of a degree farther south than the rest do. These three should obviously be rejected, and then the other accordant eight measures give for the place of this point, Kepler, 8 measures,  $37^{\circ} 43' 21''$  E. long. ;  $7^{\circ} 55' 33''$  N. lat. This result agrees entirely with the position derived from the later measures.

f. (Rosse). This name has been applied, as the point is very well placed for a point of the first order, and requires a special name. The Rosse of Webb has an unsuitable locality on the S.W. quadrant.

This Catalogue has not been delayed until the completion of the work, as this will occupy a considerable period ; and these places being in many cases far more accurate than Mädler's, will be found very useful in selenographical work now proceeding. Moreover further work in this direction has been suspended, pending a thorough examination of the Moon's limb, the irregularities on which exert considerable influence on this work.

*Chart of the Apparent Path of Mars, 1877, with Neighbouring Stars.*

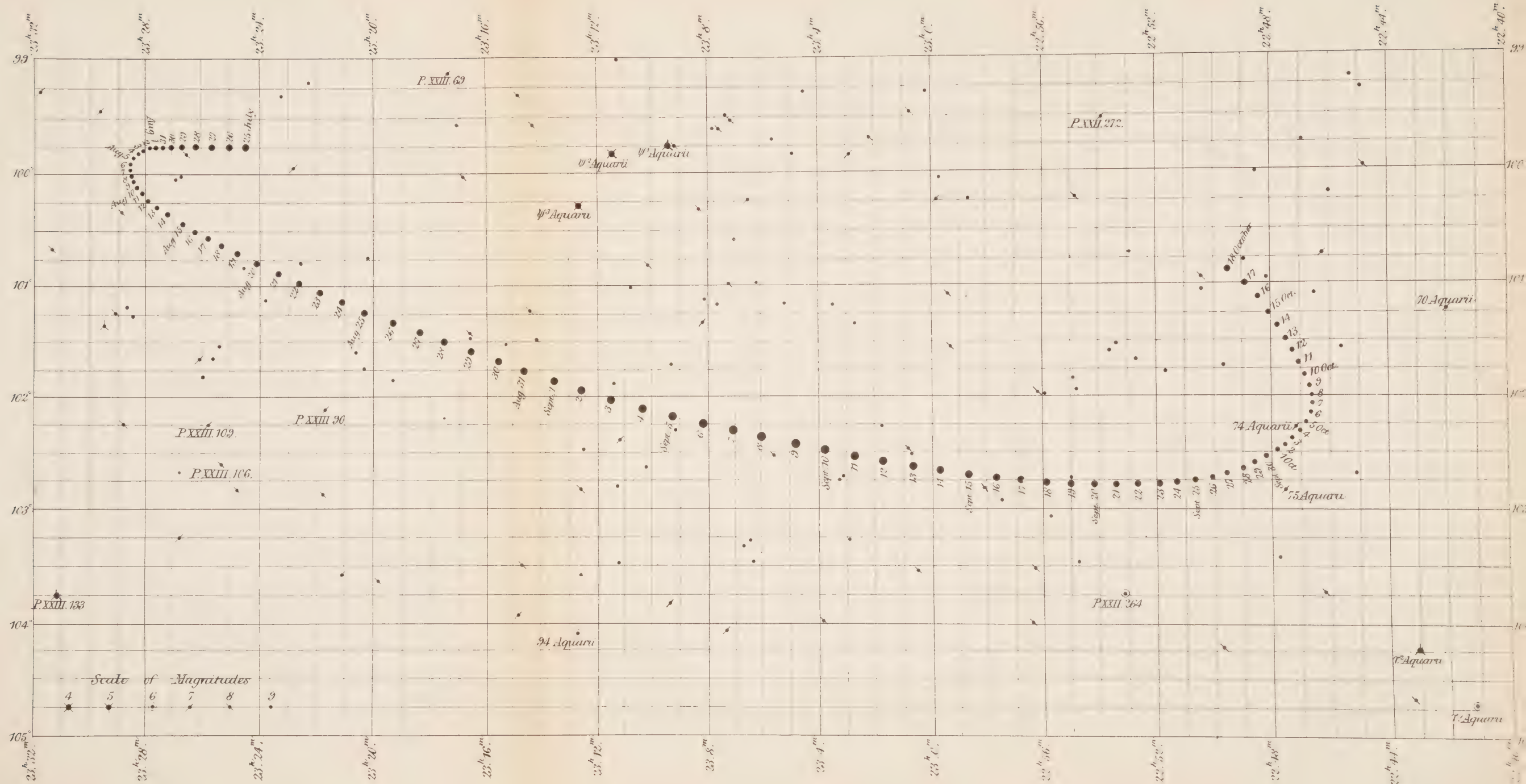
*(Communicated by the Astronomer Royal.)*

The accompanying chart has been prepared with a view of facilitating observations for the determination of the Solar parallax, the stars down to the ninth magnitude having been laid down from Bessel's "Catalogus Stellarum in Zonis Regionum" (Weisse's Bessel), applying  $+2^m 42^s$  to the R.A., and  $-17'$  to the N.P.D. of each star for precession since 1825. The daily positions of *Mars* are, for Greenwich Mean Noon.

The approximate places of the stars are given in the following table:—

# CHART OF THE APPARENT PATH OF MARS. 1877.

The Daily Positions of Mars are for Greenwich Mean Noon.





*Stars for Chart of Path of Mars, 1877, from Weisse's Bessel*  
*"Cat. Stell. in Zonis Regiomontanis."*

| No.  | Mag. | Mean R.A.<br>1877, Jan. 1. |    |    | Mean N.P.D.<br>1877, Jan. 1. |    |
|------|------|----------------------------|----|----|------------------------------|----|
|      |      | h                          | m  | s  | °                            | '  |
| 902  | 9    | 22                         | 44 | 13 | 98                           | 36 |
| 910  | 8    |                            | 44 | 44 | 99                           | 58 |
| 912  | 9    |                            | 44 | 48 | 98                           | 57 |
| 914  | 9    |                            | 44 | 53 | 99                           | 18 |
| 918  | 9    |                            | 45 | 4  | 102                          | 41 |
| 921  | 9    |                            | 45 | 19 | 99                           | 12 |
| 926  | 9    |                            | 45 | 39 | 101                          | 36 |
| 929  | 9    |                            | 46 | 0  | 100                          | 11 |
| 933  | 7    |                            | 46 | 15 | 100                          | 42 |
| 935  | 8    |                            | 46 | 17 | 103                          | 44 |
| 946  | 9    |                            | 46 | 31 | 101                          | 4  |
| 950  | 9    |                            | 46 | 44 | 101                          | 41 |
| 954  | 9    |                            | 46 | 55 | 99                           | 44 |
| 956  | 7    |                            | 46 | 57 | 102                          | 16 |
| 966  | 8    |                            | 47 | 35 | 102                          | 50 |
| 968  | 9    |                            | 47 | 45 | 103                          | 24 |
| 977  | 9    |                            | 48 | 1  | 100                          | 57 |
| 981  | 9    |                            | 48 | 28 | 100                          | 1  |
| 994  | 9    |                            | 48 | 58 | 100                          | 46 |
| 1007 | 9    |                            | 49 | 36 | 101                          | 43 |
| 1017 | 8    |                            | 50 | 20 | 100                          | 55 |
| 1020 | 9    |                            | 50 | 23 | 101                          | 3  |
| 1047 | 9    |                            | 51 | 37 | 101                          | 47 |
| 1065 | 9    |                            | 52 | 29 | 101                          | 40 |
| 1079 | 6    |                            | 53 | 4  | 103                          | 43 |
| 1086 | 9    |                            | 53 | 19 | 101                          | 32 |
| 1092 | 9    |                            | 53 | 39 | 101                          | 37 |
| 1099 | 8    |                            | 53 | 53 | 99                           | 32 |
| 1120 | 8    |                            | 54 | 41 | 100                          | 12 |
| 1121 | 9    |                            | 54 | 44 | 103                          | 28 |
| 1122 | 9    |                            | 54 | 48 | 101                          | 53 |
| 1126 | 9    |                            | 54 | 54 | 101                          | 49 |
| 1129 | 9    |                            | 55 | 0  | 102                          | 44 |
| 1145 | 9    | 22                         | 55 | 45 | 103                          | 4  |

| No.  | Mag. | Mean R.A.<br>1877, Jan. 1. |    |    | Mean N.P.D.<br>1877, Jan. 1. |    |
|------|------|----------------------------|----|----|------------------------------|----|
|      |      | h                          | m  | s  | °                            | '  |
| 1150 | 9    | 22                         | 55 | 55 | 101                          | 58 |
| 1156 | 8    |                            | 56 | 4  | 101                          | 55 |
| 1165 | 8    |                            | 56 | 18 | 103                          | 32 |
| 1166 | 8    |                            | 56 | 22 | 103                          | 59 |
| 1184 | 9    |                            | 57 | 27 | 102                          | 57 |
| 1204 | 8    |                            | 58 | 1  | 102                          | 50 |
| 1214 | 9    |                            | 58 | 36 | 100                          | 14 |
| 1231 | 8    |                            | 59 | 22 | 101                          | 33 |
| 1232 | 8    |                            | 59 | 27 | 101                          | 6  |
| 1240 | 9    |                            | 59 | 45 | 100                          | 3  |
| 1241 | 7    |                            | 59 | 50 | 100                          | 15 |
| 1245 | 9    | 23                         | 0  | 10 | 99                           | 18 |
| 1249 | 8    |                            | 0  | 30 | 103                          | 23 |
| 1254 | 9    |                            | 0  | 46 | 102                          | 31 |
| 1258 | 8    |                            | 0  | 53 | 99                           | 29 |
| 1261 | 8    |                            | 0  | 56 | 102                          | 28 |
| 1276 | 9    |                            | 1  | 53 | 102                          | 16 |
| 1279 | 8    |                            | 2  | 2  | 99                           | 40 |
| 1292 | 9    |                            | 2  | 40 | 101                          | 21 |
| 7    | 9    |                            | 2  | 54 | 99                           | 51 |
| 9    | 9    |                            | 2  | 59 | 103                          | 17 |
| 12   | 9    |                            | 3  | 11 | 102                          | 43 |
| 14   | 9    |                            | 3  | 17 | 102                          | 45 |
| 20   | 9    |                            | 3  | 30 | 101                          | 11 |
| 27   | 8    |                            | 3  | 57 | 103                          | 58 |
| 36   | 9    |                            | 4  | 29 | 99                           | 17 |
| 42   | 9    |                            | 4  | 46 | 99                           | 52 |
| 49   | 9    |                            | 5  | 3  | 101                          | 10 |
| 56   | 9    |                            | 5  | 30 | 99                           | 40 |
| 57   | 8    |                            | 5  | 32 | 102                          | 36 |
| 69   | 9    |                            | 6  | 12 | 101                          | 0  |
| 72   | 9    |                            | 6  | 21 | 103                          | 29 |
| 73   | 9    |                            | 6  | 22 | 103                          | 16 |
| 76   | 7    |                            | 6  | 34 | 100                          | 14 |
| 79   | 9    |                            | 6  | 42 | 103                          | 20 |
| 84   | 8    |                            | 7  | 4  | 99                           | 35 |
| 85   | 9    |                            | 7  | 4  | 100                          | 36 |
| 92   | 8    | 23                         | 7  | 16 | 100                          | 59 |

| No.        | Mag. | Mean R.A.<br>1877, Jan. 1. |    |    | Mean N.P.D.<br>1877, Jan. 1. |    |
|------------|------|----------------------------|----|----|------------------------------|----|
|            |      | h                          | m  | s  | °                            | '  |
| 93         | 9    | 23                         | 7  | 18 | 99                           | 28 |
| 97         | 7    |                            | 7  | 20 | 104                          | 4  |
| 101        | 9    |                            | 7  | 34 | 101                          | 10 |
| 103        | 8    |                            | 7  | 37 | 99                           | 35 |
| 104        | 8    |                            | 7  | 37 | 99                           | 36 |
| 109        | 9    |                            | 7  | 48 | 99                           | 36 |
| 118        | 9    |                            | 8  | 4  | 101                          | 8  |
| 123        | 7    |                            | 8  | 15 | 101                          | 21 |
| 124        | 8    |                            | 8  | 17 | 100                          | 21 |
| 138        | 9    |                            | 9  | 10 | 102                          | 18 |
| 143        | 9    |                            | 9  | 21 | 101                          | 43 |
| 144        | 9    |                            | 9  | 23 | 99                           | 45 |
| 146        | 7    |                            | 9  | 24 | 103                          | 51 |
| 147        | 8    |                            | 9  | 25 | 99                           | 45 |
| 156        | 8    |                            | 10 | 2  | 100                          | 53 |
| 157        | 9    |                            | 10 | 4  | 98                           | 50 |
| 160        | 9    |                            | 10 | 17 | 102                          | 38 |
| 173        | 9    |                            | 10 | 40 | 101                          | 2  |
| 185        | 7    |                            | 11 | 14 | 102                          | 23 |
| 188        | 9    |                            | 11 | 17 | 103                          | 28 |
| 189        | 9    |                            | 11 | 21 | 99                           | 1  |
| 191        | 9    |                            | 11 | 23 | 102                          | 49 |
| 193        | 9    |                            | 11 | 26 | 101                          | 56 |
| 196        | 4-5  |                            | 11 | 31 | 99                           | 51 |
| 224        | 9    |                            | 12 | 28 | 102                          | 28 |
| 226        | 5    |                            | 12 | 33 | 100                          | 18 |
| 228        | 8    |                            | 12 | 36 | 102                          | 51 |
| 94 Aquarii | 6    |                            | 12 | 37 | 104                          | 8  |
| 239        | 9    |                            | 13 | 16 | 100                          | 21 |
| 253        | 9    |                            | 14 | 3  | 101                          | 29 |
| 260        | 8    |                            | 14 | 16 | 99                           | 36 |
| 265        | 8    |                            | 14 | 28 | 101                          | 12 |
| 270        | 8    |                            | 14 | 48 | 103                          | 30 |
| 271        | 7    |                            | 14 | 49 | 103                          | 57 |
| 272        | 8    |                            | 14 | 49 | 99                           | 21 |
| 286        | 9    |                            | 15 | 19 | 101                          | 32 |
| 309        | 8    |                            | 16 | 36 | 101                          | 27 |
| 315        | 8    | 23                         | 16 | 55 | 100                          | 4  |

26 *The Astronomer Royal, Chart of Path of Mars, 1877.* XXXVI. 1,

| No.          | Mag. | Mean R.A.<br>1877, Jan. 1. |    |    | Mean N.P.D.<br>1877, Jan. 1. |    |
|--------------|------|----------------------------|----|----|------------------------------|----|
|              |      | h                          | m  | s  | °                            | '  |
| 317          | 9    | 23                         | 17 | 2  | 99                           | 34 |
| 322          | 8    |                            | 17 | 23 | 99                           | 8  |
| 323          | 7    |                            | 17 | 24 | 99                           | 8  |
| 365          | 9    |                            | 19 | 24 | 101                          | 50 |
| 373          | 8    |                            | 19 | 55 | 103                          | 38 |
| 377          | 9    |                            | 20 | 14 | 100                          | 43 |
| 381          | 9    |                            | 20 | 22 | 101                          | 43 |
| 385          | 9    |                            | 20 | 31 | 101                          | 37 |
| 394          | 7    |                            | 21 | 2  | 103                          | 36 |
| 402          | 7    |                            | 21 | 41 | 102                          | 8  |
| 403          | 8    |                            | 21 | 44 | 102                          | 53 |
| 417          | 9    |                            | 22 | 13 | 99                           | 12 |
| 423          | 9    |                            | 22 | 30 | 100                          | 47 |
| 427          | 7    |                            | 22 | 40 | 99                           | 57 |
| 440          | 9    |                            | 23 | 17 | 99                           | 21 |
| 453          | 9    |                            | 23 | 53 | 101                          | 8  |
| 463          | 9    |                            | 24 | 30 | 100                          | 50 |
| 474          | 8    |                            | 24 | 54 | 102                          | 52 |
| 483          | 9    |                            | 25 | 25 | 98                           | 51 |
| 484          | 9    |                            | 25 | 28 | 101                          | 33 |
| 485          | 8    |                            | 25 | 28 | 102                          | 38 |
| 488          | 9    |                            | 25 | 34 | 101                          | 41 |
| P. xxiii-109 | 7    |                            | 25 | 50 | 102                          | 13 |
| 495          | 9    |                            | 25 | 59 | 101                          | 50 |
| 497          | 7    |                            | 26 | 4  | 101                          | 41 |
| 508          | 8    |                            | 26 | 35 | 99                           | 51 |
| 509          | 9    |                            | 26 | 36 | 102                          | 40 |
| 514          | 9    |                            | 26 | 43 | 100                          | 3  |
| 516          | 9    |                            | 26 | 49 | 100                          | 9  |
| 519          | 7    |                            | 26 | 52 | 103                          | 17 |
| 541          | 8    |                            | 27 | 58 | 100                          | 24 |
| 556          | 9    |                            | 28 | 29 | 101                          | 16 |
| 557          | 9    |                            | 28 | 31 | 101                          | 17 |
| 562          | 8    |                            | 28 | 50 | 102                          | 16 |
| 565          | 8    |                            | 28 | 55 | 100                          | 22 |
| 571          | 8    |                            | 29 | 6  | 101                          | 14 |
| 583          | 8    |                            | 29 | 36 | 101                          | 22 |
| 585          | 9    | 23                         | 29 | 39 | 101                          | 23 |

| No. | Mag. | Mean R.A.     |    |    | Mean N.P.D.   |    |
|-----|------|---------------|----|----|---------------|----|
|     |      | 1877; Jan. 1. |    |    | 1877, Jan. 1. |    |
|     |      | h             | m  | s  | °             | '  |
| 586 | 7    | 23            | 29 | 40 | 99            | 27 |
| 617 | 5    |               | 31 | 17 | 103           | 45 |
| 619 | 8    |               | 31 | 22 | 100           | 40 |
| 629 | 7    | 23            | 31 | 52 | 99            | 19 |

*Royal Observatory, Greenwich,*  
1875, Nov. 12.

*Spectroscopic Observations made at the Royal Observatory,  
Greenwich.*

*(Communicated by the Astronomer Royal.)*

Since the establishment of the new Physical Department, the Spectroscope has been used, as opportunity offered, for the determination of the motions of stars in the direction of the visual ray, by means of the displacement of the lines of known terrestrial elements in their spectra, the line usually selected being the bluish-green line of hydrogen, corresponding to the F line of the solar spectrum. Originally the comparison between the line of hydrogen and that in the star's spectrum was made by means of a vacuum-tube placed within the tube of the Equatoreal, and at a distance of either 2 feet or 4 feet from the slit of the spectroscope, the vacuum-tube being carefully adjusted to pass through the axis of the cone of rays from the object-glass, and at right angles to it; the observation was made with the tube parallel to the slit of the spectroscope in some cases, and at right angles to it in others. A convex cylindrical lens has sometimes been used in front of the slit, to give greater breadth to the star's spectrum, though the cylindricality of the prisms themselves has usually been found sufficient for this purpose.

On 1874, August 24, two concave lenses, placed side by side, were substituted for the single concave lens in the collimator-telescope, so that the rays which returned through the collimator to the eye of the observer (after reflection from the last prism of the train used) passed through a different concave lens from that on which the incident-pencil fell. The results obtained with this arrangement appeared to be affected by a systematic error, and in consequence of this the original plan was reverted to on 1875, March 4. Suspicion being thus thrown on the method of comparison adopted (in which a narrow strip of the object-glass was used for the rays from the vacuum-tube and the rest for the rays from the star) it was abandoned, and an actual

image of the comparison-light formed on the slit immediately above and below that of the star, by means of two comparison-prisms in connection with a collimating lens, great care being taken that the cone of rays filled the whole object-glass. This method has been used regularly since 1875, May 31, the position of the image of the comparison-light on the slit having been in every case carefully adjusted before the observation. Originally the relative displacement of the star line was measured by means of the slow-motion screw acting on the train of prisms, the line being brought up to a fixed point in the field of view; but on account of the uncertainty of this method, arising from loss of time in the action of the screw (though care was taken that the weight of the prisms always acted in the same direction), a new micrometer was applied on 1874, November 27, and has been used regularly since that date.

Besides the micrometer measures, the displacement of the star line has also been estimated in terms of the width of the comparison line of hydrogen, the width of the slit being also noted, and the displacement in wave-length inferred from micrometer measures of the width of the hydrogen line under similar conditions. The width of the slit has been varied as much as possible, in order to make these estimates independent of any bias from previous results. With a view to the elimination of systematic errors as far as possible, the dispersive power has been varied as much as circumstances would allow. For a dispersive power of two prisms, the train used consists of two half-prisms, the second of which is silvered on the back, so as to reflect the rays directly back through the collimator, where they are viewed by means of a diagonal prism placed close to and on one side of the slit. The magnifying power used in this case was 37. The dispersive powers of  $1\frac{1}{2}$ ,  $2\frac{1}{2}$ , and  $3\frac{1}{2}$  prisms are given by a train commencing with a half-prism, followed by one or more whole prisms, the spectrum being viewed by a second telescope, as in ordinary spectroscopes. The small telescope has a magnifying power of 19. All the prisms are compound.

Whenever practicable, the star line has been compared directly with the  $H\beta$  line, and the relative displacement estimated. Where this could not be done, the star line was bisected by the pointer (or thick cross-wires), and the  $H\beta$  line then compared directly with the pointer before the micrometer screw was touched. The observation being necessarily made in a dark field, it was sometimes very difficult to see the pointer and star line distinctly together, and some of the measures are consequently very discordant, especially where the star line is broad and nebulous, as in the case of *Altair*, the observations of which star are entitled to very little weight.

The measures since 1875, May 31, are the most reliable, the mode of comparison being apparently free from any possible systematic error, except what might arise from the lines being "winged" through fault in the surfaces of the prisms, a

defect which would affect a bright line, and an absorption or dark line, differently. If practicable, it would be desirable to compare the star line with the absorption line of hydrogen, as seen on a continuous spectrum.

Since 1875, May 31, the astigmatism produced by the prisms has been corrected by a convex cylindrical lens, placed within the collimator, and near the slit, a convex cylindrical lens being also used in front of the slit to give breadth to the star spectrum.

The concluded motions given in the following table have been inferred from the observed displacements, after correcting for the Earth's motion, resolved in the direction of the star; the method used being the same as that adopted by Mr. Huggins in his researches on stellar motions. The velocity of light is taken as 185,000 miles a second.

## MOTIONS OF STARS IN THE LINE OF SIGHT, IN MILES PER SECOND.

(+ denotes recession; - approach.)

The observations prior to 1875, May 31, are not considered reliable; those between 1874, August 24, and 1875, March 3, are probably affected by large instrumental error.

| Date.        | Observer. | No. of<br>Prisms. | Earth's<br>Motion<br>in miles<br>per second. | Concluded Motion of Star.<br>Measured. Estimated. | Remarks.                                                                                                   |
|--------------|-----------|-------------------|----------------------------------------------|---------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <i>Vega.</i> |           |                   |                                              |                                                   |                                                                                                            |
| 1874 July 17 | W. C.     | 2                 | + 2                                          | - 104                                             | ...                                                                                                        |
| 21           | W. C.     | 2                 | + 2                                          | - 145                                             | Not very certain. Star line very ill defined.                                                              |
| Aug. 3       | M.        | 2                 | + 4                                          | - 94                                              | In each case, after bisection, the H $\beta$ line was seen its own width on the red side of the star line. |
| 11           | W. C.     | 2                 | + 5                                          | - 27                                              |                                                                                                            |
| June 25      | M.        | 2                 | - 2                                          | - 48                                              |                                                                                                            |
| 26           | W. C.     | 2                 | - 1                                          | - 16                                              |                                                                                                            |
| July 8       | M.        | 2                 | - 0                                          | - 39                                              | Everything in good adjustment.                                                                             |
| 12           | M.        | 2                 | + 1                                          | - 47                                              |                                                                                                            |
| 29           | M.        | 1½                | + 3                                          | - 38                                              | Definition good. Direct comparison.                                                                        |
| 31           | M.        | 1½                | + 3                                          | - 54                                              | Direct comparison.                                                                                         |
| Aug. 30      | M.        | 2½                | + 7                                          | - 50                                              | Very bright indeed. Direct comparison.                                                                     |
| Sept. 3      | M.        | 3½                | + 7                                          | - 29                                              | Sky hazy. Line only seen occasionally.                                                                     |
|              |           |                   |                                              |                                                   | Line broad and nebulous, and not very distinctly seen. Indirect comparison.                                |



## MOTIONS OF STARS IN THE LINE OF SIGHT, IN MILES PER SECOND.—(continued).

| Date.                             | Observer. | No. of<br>Prisms | Earth's<br>Motion<br>in miles<br>per second. | Concluded Motion of Star.<br>Measured. | Estimated. | Remarks.                                                                     |
|-----------------------------------|-----------|------------------|----------------------------------------------|----------------------------------------|------------|------------------------------------------------------------------------------|
| <i>Capella.</i>                   |           |                  |                                              |                                        |            |                                                                              |
| 1874 Dec. 4                       | M.        | 2                | - 2                                          | - 72                                   | ...        | Star line broad. Hydrogen line not well defined.                             |
| 14                                | M.        | 2                | + 1                                          | - 49                                   | ...        | Star faint. Night hazy. Direct comparison.                                   |
| 1875 Jan. 22                      | M.        | 2                | + 12                                         | - 125                                  | - 68       |                                                                              |
| <i><math>\beta</math> Aurigæ.</i> |           |                  |                                              |                                        |            |                                                                              |
| 1874 Dec. 14                      | M.        | 2                | - 2                                          | - 25                                   | - 50       | Spectrum faint.                                                              |
| <i>Sirius.</i>                    |           |                  |                                              |                                        |            |                                                                              |
| 1875 Jan. 18                      | M.        | 2                | + 4                                          | - 140                                  | - 327      | Wind high; frequent clouds. Star never long on slit. Width of slit doubtful. |
| 20                                | M.        | 2                | + 5                                          | - 96                                   | - 59       |                                                                              |
| 31                                | W. C.     | 2                | + 7                                          | - 282                                  | - 109      | Star line hardly visible, and seldom seen. Observation doubtful.             |
| Feb. 1                            | M.        | 2                | + 7                                          | - 95                                   | - 88       |                                                                              |
| Mar. 4                            | W. C.     | 2                | + 13                                         | ...                                    | ...        | Star line seen distinctly on the red side of the hydrogen line.              |
| 9                                 | W. C.     | 2                | + 13                                         | + 34                                   | + 40       | Star line not well seen. Observation very uncertain.                         |
| 10                                | M.        | 2                | + 13                                         | + 55                                   | - 1        |                                                                              |

|                                          |         |       |   |      |                                                                                                                                  |
|------------------------------------------|---------|-------|---|------|----------------------------------------------------------------------------------------------------------------------------------|
| <i>Procyon.</i>                          |         |       |   |      |                                                                                                                                  |
| 1875                                     | Mar. 6  | M.    | 2 | + 14 | - 40                                                                                                                             |
|                                          | 9       | W. C. | 2 | + 15 | - 40                                                                                                                             |
|                                          |         |       |   |      | Star line and hydrogen line nearly coincident.                                                                                   |
|                                          |         |       |   |      | Star line and hydrogen line not seen together. Displacement doubtful.                                                            |
| <i>Castor.</i>                           |         |       |   |      |                                                                                                                                  |
| 1875                                     | Mar. 10 | M.    | 2 | + 16 | + 7                                                                                                                              |
|                                          |         |       |   |      | ...                                                                                                                              |
| <i>Regulus.</i>                          |         |       |   |      |                                                                                                                                  |
| 1875                                     | Mar. 10 | M.    | 2 | + 10 | - 38                                                                                                                             |
|                                          | May 31  | M.    | 2 | + 17 | - 44                                                                                                                             |
|                                          |         |       |   |      | Image very unsteady. Star line faint at best, and often invisible. Bisection difficult and doubtful.                             |
| <i><math>\gamma</math> Ursæ Majoris.</i> |         |       |   |      |                                                                                                                                  |
| 1875                                     | May 31  | M.    | 2 | + 12 | + 62                                                                                                                             |
|                                          |         |       |   |      | ...                                                                                                                              |
| <i><math>\eta</math> Ursæ Majoris.</i>   |         |       |   |      |                                                                                                                                  |
| 1875                                     | June 11 | M.    | 2 | + 10 | + 37                                                                                                                             |
|                                          | 25      | M.    | 2 | + 10 | - 65                                                                                                                             |
|                                          | July 12 | M.    | 2 | + 9  | - 44                                                                                                                             |
|                                          |         |       |   |      | Star line very faint, and not often seen. Readings somewhat uncertain.                                                           |
|                                          |         |       |   |      | Star line scarcely visible when compared directly with H $\beta$ .                                                               |
|                                          |         |       |   |      | Star line very faint. H $\beta$ line evidently on star line, which was much the broader, and not far from the centre. Uncertain. |
| <i><math>\alpha</math> Coronæ.</i>       |         |       |   |      |                                                                                                                                  |
| 1875                                     | June 25 | M.    | 2 | + 10 | - 119                                                                                                                            |
|                                          |         |       |   |      | Star line dark, and very broad and nebulous. The two lines were not seen together.                                               |

MOTIONS OF STARS IN MILES PER SECOND (*concluded*).

| <i>α Ophiuchi.</i> |           |                |                                     |                                                         |
|--------------------|-----------|----------------|-------------------------------------|---------------------------------------------------------|
| Date.              | Observer. | No. of Prisms. | Earth's Motion in miles per second. | Concluded motion of Star. Measured. Estimated.          |
| 1875 June 25       | M.        | 2              | + 3                                 | - 26                                                    |
| July 12            | M.        | 1½             | + 7                                 | + 154                                                   |
|                    |           |                |                                     | Faint. Lines nearly coincident. Indirect comparison.    |
|                    |           |                |                                     | Faint. Not very well seen. Indirect comparison.         |
| <i>α Cygni.</i>    |           |                |                                     |                                                         |
| 1875 July 29       | M.        | 1½             | - 4                                 | + 58                                                    |
| 31                 | M.        | 1½             | - 4                                 | - 70                                                    |
| Aug. 2             | M.        | 1½             | - 4                                 | - 53                                                    |
| 30                 | M.        | 1½             | + 1                                 | - 32                                                    |
|                    |           | 2½             | + 1                                 | - 21                                                    |
|                    |           |                |                                     | ...                                                     |
|                    |           |                |                                     | Star line somewhat faint. Indirect comparison.          |
|                    |           |                |                                     | Indirect comparison.                                    |
|                    |           |                |                                     | Indirect comparison.                                    |
|                    |           |                |                                     | Indirect comparison.                                    |
|                    |           |                |                                     | Lines sensibly coincident.                              |
| <i>α Pegasi.</i>   |           |                |                                     |                                                         |
| 1875 July 29       | M.        | 1½             | - 12                                | - 10                                                    |
| Aug. 4             | M.        | 1½             | - 11                                | - 20                                                    |
| 30                 | M.        | 1½             | - 4                                 | - 66                                                    |
|                    |           |                |                                     | Star line broad and dark. Lines very nearly coincident. |
|                    |           |                |                                     | Indirect comparison.                                    |
|                    |           |                |                                     | Indirect comparison.                                    |

The results given are the means of the individual measures on the several nights of observation. The initials W. C. and M. are those of Mr. Christie and Mr. Maunder respectively.

The following measures of lines in the spectra of *Aldebaran*,  $\delta$  *Virginis*, and *Mars*, have been made by Mr. Maunder with the old star spectroscope, which has a single large prism of flint of  $60^\circ$ .

## DARK LINES IN STELLAR SPECTRA.

## Small Star Spectroscope.

The Wave-lengths are inferred from measurements of the principal Fraunhofer lines, made on 1875, April 7, combined with measures of the bright lines of certain elements given below.

*Aldebaran.*

1874, Nov. 24.

| Micrometer.<br>Rev. | Intensity. | Wave-length.<br>Tenth-metres. | Elements. |
|---------------------|------------|-------------------------------|-----------|
| 49.227              | 4          | 5890                          | Sodium.   |
| 48.308              | 2          | 5840                          |           |
| 46.980              | 2          | 5755                          | Iron.     |
| 44.708              | 1          | 5575                          | Iron.     |
| 40.984              | 2          | 5440                          | Iron.     |
| 39.158              | 2          | 5340                          | Iron.     |
| 38.749              | 3          | 5320                          | Iron.     |
| 37.895              | 4          | 5280                          | Iron.     |

1874, Dec. 2.

| Micrometer.<br>Rev. | Intensity. | Wave-length.<br>Tenth-metres. | Elements.  |
|---------------------|------------|-------------------------------|------------|
| 37.372              |            | 5170                          | Magnesium. |
| 32.789              |            | 4990                          | Air.       |
| 50.737              |            | 5870                          | Sodium.    |

1874, Dec. 2.

Measures of Bright Lines from Spectra of Elements, for comparison,  
made at the same time as above.

| Micrometer.<br>Rev. | Assumed Wave-length.<br>Tenth-metres. | Elements.            |
|---------------------|---------------------------------------|----------------------|
| 15.544              | 4480                                  | Magnesium.           |
| 29.253              | 4861                                  | Hydrogen H $\beta$ . |
| 36.935              | 5167                                  | Magnesium ( $b_4$ ). |
| 37.267              | 5183                                  | Magnesium ( $b_1$ ). |
| 32.815              | 5005                                  | Air.                 |
| 50.872              | 5892                                  | Sodium (D).          |

The assumed Wave-lengths are taken from Watts' *Index of Spectra*.

Micrometer A used throughout.

## 8 Virginis.

1875, April 13.

This Spectrum is crossed by seven dark bands which shade off on the red side, and have the appearance of being composed of a number of fine lines. The bands are numbered from the red.

| No. of Band.   | Micrometer.<br>Rev. | Wave-length.<br>Tenth-metres. | Remarks.                             |
|----------------|---------------------|-------------------------------|--------------------------------------|
| I.             | ...                 | ...                           | Too faint to measure.                |
| II.            | ...                 | ...                           | Too faint to measure.                |
| III.           | 27'939              | 5420                          | Sharp edge (on the violet side).     |
| IV. 1st edge   | 31'690              | 5255                          |                                      |
| 2nd edge       | 32'646              | 5210                          | Very black.                          |
| V. Sharp edge  | 38'446              | 4960                          | Edge on the violet side.             |
| VI. Sharp edge | 44'204              | 4790                          | Edge on the violet side. Band faint. |
| VII.           | ...                 | ...                           | Too faint to measure.                |

Assumed Wave-length.  
Tenth-metres.

|            |        |      |                                  |
|------------|--------|------|----------------------------------|
| H $\alpha$ | 11'000 | 6562 | From vacuum tube for comparison. |
| H $\omega$ | 41'719 | 4861 |                                  |

Micrometer B used throughout.

## DARK LINES IN SPECTRUM OF MARS.

Small Star Spectroscope.

1875, July 1.

| Micrometer. | Wave-length. | Elements.      | Remarks.             |
|-------------|--------------|----------------|----------------------|
| 10'263      | 6560         | Hydrogen       | C line.              |
| 11'158      | 6465         | Calcium        |                      |
| 13'742      | 6257         | Iron           |                      |
| 14'225      | 6217         | Titanium       |                      |
| 15'052      | 6153         | Sodium or Air. |                      |
| 18'210      | 5940         | Air            | Very dark line.      |
| 18'506      | 5923         | Air            | Dark line.           |
| 18'840      | 5900         | Sodium         | D <sub>1</sub> line. |
| 18'904      | 5895         | Sodium         | D <sub>2</sub> line. |
| 19'782      | 5835         |                | Dark line.           |
| 23'274      | 5625         | Iron           |                      |
| 24'475      | 5560         | Air            |                      |
| 25'715      | 5495         | Iron or Air    |                      |
| 29'282      | 5337         | Iron           |                      |
| 29'927      | 5305         | Iron           |                      |

| Micrometer. | Wave-length. | Elements. | Remarks.    |
|-------------|--------------|-----------|-------------|
| 30·610      | 5270         | Iron      |             |
| 31·484      | 5230         | Iron      |             |
| 31·945      | 5205         | Chromium  |             |
| 32·503      | 5183         | Magnesium | $b_1$ line. |
| 32·802      | 5170         | Magnesium | $b_2$ line. |
| 32·922      | 5165         | Magnesium | $b_4$ line. |

Micrometer B used throughout.

Image tremulous.

The part of the Spectrum, lying southwards from its centre, for one-third of the breadth of the Spectrum was much fainter than the rest. The slit was narrow, and lay north and south.

Besides observations of prominences, the following measures of the widths of some of the Fraunhofer lines have been made by Mr. Christie with the powerful spectroscope which Mr. Spottiswoode kindly lent during the adjustment of the Observatory spectroscope.

#### MEASURES OF THE WIDTH OF FRAUNHOFER LINES.

Taken with the Spottiswoode Spectroscope.

1875, September 16.

| Line.          | Measured Width.<br>Rev. | Wave-length corresponding to 1 Rev.<br>Tenth-metres. | Width in Wave-length.<br>Tenth-metres. | Remarks.                                                                     |
|----------------|-------------------------|------------------------------------------------------|----------------------------------------|------------------------------------------------------------------------------|
| C              | 0·167                   | 6·38                                                 | 1·065                                  |                                                                              |
| D <sub>1</sub> | 0·077                   | 4·31                                                 | 0·332                                  | D <sub>2</sub> was to the eye broader and more nebulous than D <sub>1</sub>  |
| D <sub>2</sub> | 0·116                   | 4·31                                                 | 0·500                                  |                                                                              |
| $b_1$          | 0·057                   | 2·91                                                 | 0·166                                  | $b_1$ seemed a thin line in the middle of a haze.                            |
| Haze           | 0·533                   | 2·91                                                 | 1·551                                  |                                                                              |
| $b_2$          | 0·220                   | 2·91                                                 | 0·640                                  |                                                                              |
| $b_3$          | 0·068                   | 2·91                                                 | 0·198                                  | Two lines: a black line on the red side, and a faint nebulous line the blue. |
| $b_4$          | 0·200                   | 2·91                                                 | 0·582                                  |                                                                              |
| F              | 0·518                   | 2·19                                                 | 1·134                                  |                                                                              |

Width of Slit = 0·001 inch.

*Royal Observatory, Greenwich,*  
1875, Nov. 12.

*Observations of the Solar Eclipse of 1875, September 28-29, made at the Royal Observatory, Greenwich.*

*(Communicated by the Astronomer Royal.)*

The circumstances of this Eclipse, like that of 1874, October 9, were not favourable for the determination of the corrections to the diameter of the Sun and Moon. On this occasion the magnitude of the Eclipse was only 0.119, the diameter of the Sun being unity. In consequence, observations were made with the Great Equatoreal, with a view only of determining the corrections to the tabular place of the Moon in R.A. and N.P.D., the corrections to the diameters being adopted, as in the reductions of the previous eclipse, from the results of the eclipse of 1870, December 21-22, which were obtained by the same observers.

Taking  $da$  = Correction to excess of Moon's R.A. over Sun's R.A.

$d\delta - d\Delta$  =        "        "        "        N.P.D.        "        "        N.P.D.

$dS$  =        "        Sun's semidiameter

$ds$  =        "        Moon's        "

two series of measures were made, the telescope-observations being made by Mr. Christie, and the declination-microscopes read by Mr. Criswick.

(1). Differences of N.P.D. of the upper and lower cusps during about half an hour following the first contact, which show principally the effect of the correction

$$+ da, + dS, + ds.$$

(2). Differences of R.A. of right and left cusps during about forty minutes preceding the last contact, which show principally the effect of the correction

$$+ (d\delta - d\Delta), + dS, + ds.$$

Two resulting equations were formed from these differences by taking the sums of the constituent equations obtained by a comparison of the measured with the tabular quantity, as affected by the symbolical corrections for each of the two series of observations.

The adopted value of  $dS$  being  $-1''.679$ , and of  $ds$  being  $-0''.492$ ,

$$da = -10''.83 = -0^s.722$$

$$d\delta - d\Delta = -3''.98.$$

From 14 meridional observations of the Sun from Sep-

tember 13 to October 16, the corrections to the Sun's tabular place were found to be

$$\begin{aligned}\text{in R.A.} &= -0^{\circ}09 \\ \text{in N.P.D.} &= -1''34.\end{aligned}$$

Combining these corrections with the corresponding results of the Equatoreal observations, the following corrections to the Moon's tabular place are obtained :

$$\begin{aligned}\text{in R.A.} &= -0^{\circ}81 \\ \text{in N.P.D.} &= -5''32.\end{aligned}$$

Observations of the R.A. and N.P.D. of each cusp were also made by Mr. Downing with the Transit-circle. Treating these in a similar manner to the Equatoreal observations, but adopting  $-0''53$  for the correction to the Sun's semi-diameter determined from a long series of observations with the Transit-circle, and the correction of the Moon's semi-diameter from the results of the eclipse of 1870, December 21-22, observed with the Great Equatoreal, the following corrections are deduced :

$$\begin{aligned}da &= -13''53 = -0^{\circ}902 \\ d\delta - d\Delta &= -5''88.\end{aligned}$$

Substituting these values for  $da$  and  $d\delta - d\Delta$  in the original equations, in addition to those for  $dS$  and  $ds$ , the following are the resulting corrections to the tabular places of the Sun and Moon :

$$\begin{aligned}\text{Correction to Tabular R.A. of Sun} &= +1''04 = +0^{\circ}069 \\ \text{,, ,, N.P.D. ,,} &= -0''23. \\ \text{Correction to Tabular R.A. of Moon} &= -12''48 = -0^{\circ}832 \\ \text{,, ,, N.P.D. ,,} &= -6^{\circ}11.\end{aligned}$$

Fourteen photographs were taken with the photoheliograph during the eclipse.

The following table contains the observations of the beginning and ending :

*Observations of the Beginning of the Eclipse.*

|     | Instrument.       | Clock or Chronometer. | Mean Solar Time.<br>d h m s | Observer. |
|-----|-------------------|-----------------------|-----------------------------|-----------|
| (a) | E. Equatoreal     | Earnshaw              | 28 23 30 7.1                | D.        |
| (b) | Altazimuth        | Graham 1              | 23 31 10.8                  | L.        |
| (c) | Simms 4-in. No. 2 | Brockbanks 436        | 23 30 13.8                  | A. D.     |
|     | 6-in. Equatoreal  | Webb 5380             | 23 31 39.3                  | C. B. N.  |
| (d) | 2½-in. Altazimuth | Dent 2015             | 23 30 4.0                   | J. W. N.  |

*Observations of the Ending of the Eclipse.*

|     | Instrument.      | Clock or Chronometer. | Mean Solar Time. |   |    |      | Observer. |
|-----|------------------|-----------------------|------------------|---|----|------|-----------|
|     |                  |                       | d                | h | m  | s    |           |
| (e) | S. E. Equatoreal | Sid. Standard         | 29               | 0 | 51 | 16.6 | W. C.     |
| (f) | E. Equatoreal    | Earnshaw              |                  | 0 | 51 | 16.7 | D.        |
| (g) | Altazimuth       | Graham 1              |                  | 0 | 51 | 21.6 | L.        |
|     | Lee Equatoreal   | Frodsham 3449         |                  | 0 | 51 | 3.6  | G. L. T.  |
|     | 6-in Equatoreal  | Webb 5380             |                  | 0 | 50 | 56.1 | C. B. N.  |
| (h) | 2½-in Altazimuth | Dent 2015             |                  | 0 | 51 | 2.6  | J. W. N.  |

*Notes.*—(a) Very tremulous. Power 140. (b) Time recorded uncertain. (c) Power 76. (d) Probably from 10 to 20 seconds late. (e) Power 295. (f) Observed through cloud. (g) The observation was considered good. (h) The last contact may have occurred at the recorded time  $\pm 7^s$ .

The initials of the Observers, W. C., D., L., A. D., G. L. T., C. B. N., and J. W. N., are those of Mr. Christie, Mr. Dunkin, Mr. Lynn, Mr. Downing, Captain Tupman, Lieutenant Neate, and Mr. Nichol.

*Royal Observatory, Greenwich,  
1875, November 12.*

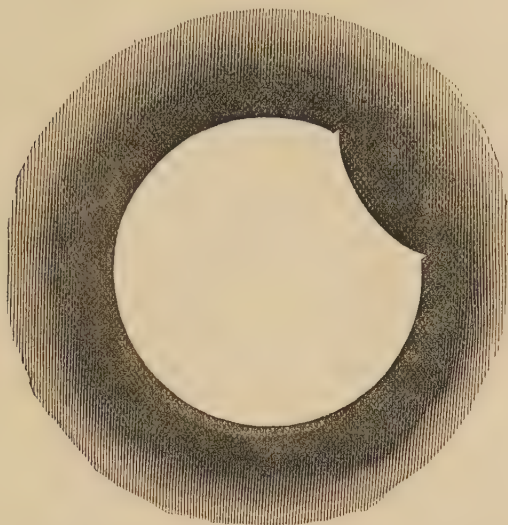
*Partial Eclipse of the Sun, September 28-29, 1875, observed at  
Forest Lodge, Maresfield. By Capt. Wm. Noble.*

I constricted the aperture of the object-glass of my Equatoreal to 2.3 inches, and observed with a power of 74 and a dark-green eye-shade. The atmospheric undulation was very great indeed. As far as I could determine, the first perceptible indentation on the limb of the Sun occurred at

11<sup>h</sup> 57<sup>m</sup> 5<sup>s</sup> L.S.T. = Sept. 28, 23<sup>h</sup> 25<sup>m</sup> 49<sup>s</sup> L.M.T.

The limb of the Moon was very notably smooth. Before, during, and after the time of greatest obscuration, the Sun's limb appeared to turn *very* slightly outwards—perhaps to the extent of 1" or 1".5—where that of the Moon cut it, giving rise to the effect of two little thorns of light projecting from it. It suggested the idea of very slight refraction of the Sun's light at the limb of the Moon. In order to eliminate anything in the shape of personal equation, and to be certain that this was an actual objective appearance, I got Mr. Noble, and Mr. J. Lister-Godlee of the Equity Bar, successively to view the eclipsed Sun, and to describe what they saw; and in each case the little

thorns of light were at once detected and mentioned by the observer. The accompanying sketch indicates this appearance very fairly.



The last contact, which I observed through massive driving cumuli, I believe to have occurred at

13<sup>h</sup> 20<sup>m</sup> 26<sup>s</sup> L.S.T. = Sept. 29, 0<sup>h</sup> 48<sup>m</sup> 56<sup>s</sup> L.M.T.

*Phenomena of Jupiter's Satellites, observed at Mr. E. Crossley's Observatory, Bermerside, Halifax, with the 9 $\frac{1}{2}$  inch Cooke Refractor. By Edward Crossley, Esq., F.R.A.S., and Mr. Joseph Gledhill, F.R.A.S., F.G.S., &c.*

| Date.<br>1875. | Satellite | Phenomenon.              | G.M.T. |    |    | Observer.        | Remarks.                                    |
|----------------|-----------|--------------------------|--------|----|----|------------------|---------------------------------------------|
|                |           |                          | h      | m  | s  |                  |                                             |
| April 13       | I.        | Ec.D. first beg. to fade | 9      | 17 | 53 | E. C.<br>& J. G. | Good.                                       |
|                |           | half gone                | 18     | 18 |    | "                | Fair.                                       |
|                |           | disappeared              | 19     | 18 |    | "                | Good.                                       |
|                | I.        | Öc.R. first seen         | 11     | 29 | 30 | J. G.            | May be 20 sec. in error!<br>bad definition. |
|                |           | half out                 | 31     | 0  |    | "                | Pretty good.                                |
|                |           | quite clear of disk      | 33     | 0  |    | "                | Pretty good.                                |

| Date.<br>1875. | Satellite. | Phenomenon.          | G.M.T.<br>h m s | Observer.        | Remarks.                                                                                           |
|----------------|------------|----------------------|-----------------|------------------|----------------------------------------------------------------------------------------------------|
| April 19       | I.         | Tr. I. first contact | 13 46 54        | "                | May be 30 sec. in error;<br>bad definition.                                                        |
|                |            | bisection            | 48 24           | "                | Not good.                                                                                          |
|                |            | last contact         | 49 54           | "                | Pretty good.                                                                                       |
|                | I.         | Sh. I. fully on disk | 13 54 24        | "                | May be 30 sec. in error;<br>bad definition.                                                        |
| April 28       | I.         | Tr. I. first contact | 9 57 57         | E. C.<br>& J. G. | Uncertain; no definition.                                                                          |
|                |            | bisection            | 59 27           | "                |                                                                                                    |
|                |            | just within          | 10 1 27         | "                |                                                                                                    |
|                | I.         | Sh. I. first seen    | 10 16 27        | J. G.            | About bisected.                                                                                    |
|                | I.         | Tr. E. first contact | 12 6 27         | "                |                                                                                                    |
|                |            | bisected             | 8 27            | "                |                                                                                                    |
|                |            | just clear           | 11 27           | "                |                                                                                                    |
| May 14         | I.         | Tr. E. first contact | 10 4 4          | "                | Fair.                                                                                              |
|                |            | bisected             | 5 4             | "                | Fair.                                                                                              |
|                |            | last contact         | 7 34            | "                | Good.                                                                                              |
|                | I.         | Sh. E. first contact | 10 42 34        | "                | Fair.                                                                                              |
|                |            | bisected             | 44 34           | "                | Fair.                                                                                              |
|                |            | last contact         | 46 34           | "                | Fair.                                                                                              |
| May 22         | I.         | Ec. R. first seen    | 9 53 49         | "                | Perhaps 0.5 sec. late:<br>fair definition.                                                         |
|                |            |                      | 54 28           | E. C.<br>& J. G. | Uncertain.                                                                                         |
|                |            | full brightness      | 55 40           | "                | Probably good.                                                                                     |
| June 13        | I.         | Tr. I. first contact | 9 33 28         | J. G.            | Pretty good.                                                                                       |
|                |            | bisected             | 35 58           | "                | Not reliable.                                                                                      |
|                |            | last contact         | 37 58           | "                | Pretty good.                                                                                       |
|                | I.         | Sh. I. first seen    | 10 40 0         | "                | Partly on disk: at<br>10 <sup>h</sup> 43 <sup>m</sup> 28 <sup>s</sup> just fully<br>on disk, prob. |
| June 14        | I.         | Ec. R. first seen    | 10 5 39         | "                | Very bad definition.                                                                               |
|                | II.        | Ec. R. first seen    | 49 14           | "                |                                                                                                    |
|                |            | full brightness      | 54 0            | "                |                                                                                                    |

*Mr. Edward Crossley's Observatory,**Bermerside, Halifax.**September 29, 1875.*

*Occultation of Mars, observed at Windsor, N.S.W.*

By John Tebbutt, Esq.

An occultation of the planet *Mars* by the Moon occurred here in full daylight on August 12, and was pretty well observed by means of the  $4\frac{1}{2}$ -inch Equatoreal, and a power of 55. The disappearance took place at the dark limb, the first and last contact being noted at  $2^h 58^m 10^s.9$ , and  $2^h 58^m 40^s.9$ , local mean time, respectively. The rapid disappearance of the planet's disk was an exceedingly interesting phenomenon, its extinction taking place at a considerable distance from the Moon's illuminated disk. The line marked by the Moon's dark limb across the planet's disk was well defined, and appeared to move very rapidly till the last trace of the planet disappeared. Several small clouds were scattered over the sky during the afternoon and one of these unfortunately prevented the complete observation of the reappearance. Just as the Moon was emerging from the cloud the planet was observed as a small projection on the bright limb. I found it extremely difficult to fix the precise instant of the last contact owing to the ill-defined nature of the planet's eastern limb. This want of definition was due to the defective illumination of the limb, the planet being considerably past its opposition, and therefore gibbous. The western limb was, however, sharply defined. The last contact was noted at  $4^h 1^m 24^s.9$ ; the separation was entirely complete by  $4^h 1^m 27^s.9$ .

I may mention that, although the records of the Observatory for the past ten years contain a long list of lunar occultations of fixed stars, this is the only instance of an observed occultation of a planet.

*Private Observatory,*

*Windsor, N. S. Wales,*

1875, August 27.

*Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield. By Capt. Wm. Noble.*

*Occultation of  $\zeta$  Arietis, October 16, 1875.*

The star seemed to sink into the Moon's bright limb at

$$22^h 59^m 48^s.7 \text{ L.S.T.} = 9^h 19^m 53^s.58 \text{ L.M.T.}$$

It re-appeared instantaneously at the dark limb at

$$23^h 54^m 23^s.7 \text{ L.S.T.} = 10^h 14^m 19^s.64 \text{ L.M.T.}$$

Power 135, a positive (micrometer) eye-piece being em-

ployed on my Ross Equatoreal of 4'2 inches aperture and 61 inches focal length.

*Occultation of  $\chi$  Aquarii, November 8, 1875.*

The star disappeared instantaneously at the Moon's dark limb at

$0^h 43^m 5^s.9$  L.S.T. =  $9^h 32^m 27^s.96$  L.M.T.

The reappearance was not observed. Power 77 with a positive (micrometer) eye-piece.

*Note on a Successful Attempt to support a Mercury Trough by a compact and easily removable Arrangement.*

By Col. J. F. Tennant, R.E., F.R.S.

Where the level error of a Transit Instrument, or the nadir point of a transit circle, is to be found by reflection of its wires from mercury, it becomes necessary to support the mercury trough, so as to ensure freedom from tremors. I have been much troubled with the job of doing this, and having succeeded in securing a practical result, think that the mode in which I have done it will be interesting to members of the Astronomical Society.

My Transit Instrument stands on a single pier on a solid metal round base, supported by three of Colonel Strange's foot screws; there is a diametral ridge about an inch high in the middle, and four inches wide on this joining the two pillars, and above this again come the arms which raise the transit-axis, and, when turned on the centre, enable it to be readily reversed. The object end of the telescope, when the counterpoises necessary to put the two ends of the telescope in equilibrium are attached, comes within an inch of the reversing carriage, and it has not been easy to get a steady support for the mercury owing to the very confined space for it.

Messrs. Cooke and Sons supplied an iron trough which rested on the reversing carriage. This was simply intolerable, and after trying it I had to give it up at once. I have hardly ever seen the wires in it. Captain Campbell first made a wooden bridge over the reversing arrangement, placing the mercury in a hollow and supporting it on blocks of wood; but this was difficult to remove for observing, and, though the wires *were* seen, it was evident to me that an arrangement of this sort would not answer, as vibrations would be too readily propagated. I then made a trough of amalgamated copper (I believe the idea is Prof. Pritchard's), and supported it in an iron tray on a layer

of sand; the tray was carried on wooden blocks, with small pieces of sheet india-rubber to aid in deadening the vibrations by increasing the number of surfaces where there was a change of elasticity. This was used in December last, and I hoped I had conquered the difficulty, but the time was very favourable as there was (owing to the cold) no traffic at night. When the weather became warm it became manifest that I must either give up the observation by reflection, or devise some means of destroying tremor. I never hardly could get a bearable image of the wires till long after midnight, and to set half a dozen observations entailed an hour's watching.

I have now made two blocks, each a couple of inches high, consisting of six sheets of deal and an equal number of printer's blankets glued together, care being taken not to let the glue penetrate the blankets; these form piers carrying a board, supporting a large and flat dish of mercury. The result, as I anticipated, is excellent; unless carriages are passing along roads only 100 yards off, I have usually reflected wires as sharp as those seen directly. I have yet to devise some plan of avoiding glue, which will certainly yield in India, &c.; it was in the hopes of doing this that I have delayed making up the apparatus till the closing of the rainy season made action necessary.

It will be seen that the great advantage of this form of support is its extreme compactness. The use of such a suspension as that for the mercury of the Reflex Zenith Tube at Greenwich was out of the question here, both from want of space and inability to procure india-rubber, and to preserve it when got. Probably the ultimate form for use here will be a box containing coarse millboard and printer's blankets in alternate layers, but the present arrangement is more compact than anything could be made without the use of glue.

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*Note on Prof. Pritchard's Ephemeris of Circumpolar Stars.*

By Colonel Tennant, R.E., F.R.S.

In the January number of the *Monthly Notices* (Vol. XXXV. p. 113) is a paper giving the places of 12 close circumpolar stars for the current year, in the course of which Professor Pritchard expresses a hope that the Director of the *Nautical Almanac* would take into consideration the question of publishing such Ephemerides in future. In this hope I cordially join; but I am doubtful if the stars chosen in this paper would be generally suitable.

If the ends of the great body of amateurs who have not a computing staff, and of moving astronomers, official or private, can be served as well as those of Observatories having powerful

instruments, it would, I think, be desirable. I have no doubt that other parties employed, like myself, for the late Transit of *Venus*, have felt greatly the want of circumpolar stars, and the want will be again felt in 1882. Few have had more powerful means of observing transits than myself, yet stars so small as most of those of the Oxford list would have been quite useless to me, and I should have been obliged to select some (as I have done) from such Catalogues as were available. Another reason why I think a better selection might be made is, because I doubt whether the *close* circumpolar stars are either the most convenient or most accurate for determinations of azimuth. I find that stars 10 or 12 degrees distant from the Pole are far more accurately observed, and they have the great advantage that they pass the wires much more quickly.

I think, then, that the stars selected should, if possible, not be of less than 6.5 magnitude, that they may be generally available; and that no loss of practical accuracy would result if the limit of polar distance were  $15^{\circ}$ . I do not offer my own selection, as it was made entirely from the Greenwich Catalogues, and is very defective, especially in the early hours of Right Ascension. This has partly arisen from my not using stars which had been observed very few times, but more from an apparent want of large stars in that part of the sky. It is probable, however, that a better selection may be made. If satisfactory means of determining the azimuthal correction of the Transit in each sidereal hour could be given, it would be a very great boon to many establishments where time is wanted, but where meridional observation is not a principal object.

Roorkee, September 26, 1875.

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*On the Aspect of the Zodiacal Light opposite the Sun.*

By T. W. Backhouse.

I have lately observed a curious phenomenon respecting the Zodiacal Light which I have never heard described before; that is, a comparatively bright patch opposite the Sun. It does not appear to be generally known that the Zodiacal Light is visible at all opposite the Sun; but it is so, very commonly. But the phenomenon I now refer to is one I never noticed with such distinctness previous to September 28; on which night there was, in *Pisces*, a remarkably definite oval patch of light about  $20^{\circ}$  by  $14^{\circ}$  in diameter. Its boundary was at  $\epsilon$ ,  $\omega$ ,  $21$  and  $29$  *Piscium*, and  $13$  and  $20$  *Ceti*. Further west the Zodiacal Light faded away very suddenly; indeed at first (at  $10^{\text{h}} 15^{\text{m}}$ ) I could not perceive it any further in this direction; but afterwards I could trace it, though extremely faint, to  $\sigma$  *Aquarii*. East of the

bright patch it faded more gradually, but at first rapidly; and was visible to near the *Pleiades*, beyond which it was rendered invisible by the Milky Way. Southwards I could, later on, trace the light, though very faint, to  $\iota$  *Ceti*; and northwards to  $\gamma$  *Pegasi*, if not beyond. East and west of the bright patch, the Zodiacal Light was only  $10^\circ$  or  $12^\circ$  wide.

At 10.45 I perceived that the light of the bright patch was far from uniform, being rapidly concentrated, chiefly nearly along the ecliptic; the brightest part was at, or  $1^\circ$  north of, 44 *Piscium*. This point I find was exactly, to a degree, opposite the Sun. The phenomenon continued much the same up to 11<sup>h</sup> 50<sup>m</sup>; and during the succeeding 10 days the point of maximum brightness gradually moved eastwards among the stars: the bright patch appearing, however, less definite.

On examining my old Notes, I find that although I never before saw so definite a patch of light opposite the Sun, still I have records of six previous instances when the light within a few degrees of the point opposite the Sun was brighter than that some distance further *p* and *f*, besides one where the greater faintness of the light *f* that point is rather doubtful. Besides these, I find 14 nights (previous to this autumn) when the light was brighter opposite the Sun than on one side of that region, the other side being obscured by the Milky Way or from some other cause. On the other hand, on October 16, 1868, I could not see the Zodiacal Light at the point opposite the Sun, though it was just perceptible a little further *f*. Also I have often seen it in that region without noticing any inequalities in it.

These discrepancies are not to be wondered at, when we consider the faintness of the phenomenon. I cannot say whether the bright patch has *really* been exceptionally definite of late; or whether it is only that my eyes have become better able to see it. The likelihood of such an occurrence is not sufficiently borne in mind by observers; who, when they see the Zodiacal Light brighter than they ever did before, are apt to conclude it has increased in brightness; while really it may only be that their eyes have become more sensitive to it. All that part of it opposite the Sun, though quite plain to my eyes, is of course very faint—so faint that it is quite doubtful whether it would be visible to a person whose eyes had not been trained to see objects of the kind. I never saw this part till 1868, though I have observed the Zodiacal Light since 1861.

Taking these circumstances into account, it seems probable that the Zodiacal Light is *always* brighter at the point of the sky opposite the Sun than at a little distance on each side of that. I have not made many observations of the actual intensity of this light; but it is probably about equal to that part of the Zodiacal Light  $100^\circ$  or  $110^\circ$  off the Sun; also to the Milky Way in the greater part of *Perseus*.

As to the cause of this phenomenon: it is highly improbable that there long protuberance of the lenticular disk (which is

generally thought to be the shape of the Zodiacal Light), away from the Earth ; and one is reminded of the anthelion on dew, but it is not likely we have in this case to deal with drops : but it is still possible that the zodiacal light is composed of particles which reflect light more readily straight towards the Sun than at other angles.

I subjoin the position of the brightest part of the light on every night on which I have seen it pretty definite. The longitude given is the distance *f* the Sun. In making nearly all these observations I was quite unaware of the actual position among the stars of the point opposite the Sun ; so that my judgment of the position of maximum brightness was quite unbiassed.

| Year. | Mo. | Day. | Long. <i>f.</i> Sun. | Lat. | Year. | Mo. | Day. | Long. <i>f.</i> Sun. | Lat. |
|-------|-----|------|----------------------|------|-------|-----|------|----------------------|------|
| 1871  | 11  | 8    | 185                  | +3   | 1875  | 10  | 4    | 180                  | 0    |
| 1872  | 10  | 9    | about 182            | 0    |       | 10  | 5    | 179                  | 0    |
| 1874  | 10  | 3    | „ 186                | +2   |       | 10  | 6    | near 183             | 0    |
|       | 11  | 6    | „ 185                | +3   |       | 10  | 8    | „ 181                | +1   |
| 1875  | 9   | 28   | 180                  | 0    |       | 11  | 5    | 189-180              | 0    |
|       | 10  | 2    | 179                  | 0    |       | 11  | 7    | 186-178              | +2   |

Sunderland, November 9, 1875.

### *Observations of the Zodiacal Light at Cadiz.*

By Señor A. T. Arcimis.

(Abstract of a Paper published in the "*Buletino Meteorologico del Collegio Romano.*")

FOR many years I have observed this phenomenon without the assistance of any instrument ; but latterly, in February and subsequent months, I have made use of the spectroscope for the analyses of this luminous manifestation. The results of my investigations are contrary to the conclusions of Prof. Wright, of Yale College, and, notwithstanding my perfect confidence in what I have observed, I did not dare to publish a work that would be received probably with some diffidence without the powerful incitement of the illustrious Director of the Observatory of Rome.

In order that the reader may appreciate the accuracy of these observations, I think it right to give an account of the place where they were taken, and the instruments employed.

The city of Cadiz forms an almost regular polygon of five kilometers of perimeter, surrounded by the sea on all sides except on the east, where a narrow neck of land runs towards the mainland.

My Observatory is established at the top of the tower of my own house, situated to the N.N.W. of the city, at a height of 131 feet above the level of the sea, and in favourable weather I can see an horizon of twelve miles radius. There being no factories in this city, the smoke of the furnaces of which might obscure the air, the thermal equilibrium is re-established between land and sea shortly after sunset; the purity of the air and the small extension of the city admitting a rapid cooling.

The aspect presented to the naked eye on the horizon of Cadiz by the Zodiacal Light is a very interesting one. Its brilliancy is superior to the Milky Way in its most conspicuous part; its colour is not homogeneous in all the extension of the spindle, nor the same every evening. It is whitish from the apex to  $30^{\circ}$  or  $40^{\circ}$ , and from that height to the horizon it becomes yellowish or reddish. The resemblance of this tint with those of the eclipsed moon gave me the idea that this cupreous tint would be produced by our atmosphere. I observed attentively the setting of the Light, and the whitish or milky portion remained unchanged.

I have repeatedly made this observation in favourable evenings, always with the same result.

The altitude of the vertex has been determined by comparisons with some of the stars, the highest being  $70^{\circ}$ .

Sometimes I have seen to the east a kind of luminousness, not belonging to the twilight, because it lasted three or four hours after sunset. Its form is that of an iron lance, and it is of a whitish colour.

In some instances the Light presented, in all its extension, a vibratory movement; but I cannot say if this was in consequence of the weariness of my sight; as in other evenings the placidity of the splendour lent a more mysterious character to the phenomenon.

Having made the description of the Light as seen by the naked eye, I proceed to record its spectrum analysis; the observations have been conducted carefully, and without any preconceived idea, and I am perplexed in considering the discordance that exists between Prof. Wright's results and my own. He has worked with accurate instruments, but his conclusions are negative; and, although my means are modest, the observations were made repeatedly, and the results are positive. I should not doubt that his conclusions are right, but at the same time I am convinced of the correctness of my own.

With a pocket spectroscope, that I directed to the central and lowest portion of the cone, I immediately detected a continuous spectrum, I can say monochromatic, similar to those exhibited by the train of some falling stars. After a short time, and familiarised with the spectrum, I detected a faint yellowish or greenish line, which I first thought to be the sodium line, but I soon convinced myself that it was more refrangible. Widening the slit, the line appeared broader, whilst it lost much of its

brilliancy. The spectrum was also visible in other parts of the sky, especially in the splendour of the east, where the greenish line appeared more vaporous. I made use of a meteor spectro-scope, and detected the continuous spectrum accompanied by two luminous expansions, which were situated in the yellow and blue.

I then applied the refractor armed with a five-prisms spectro-scope by Hoffmann. The greenish line was situated between *D* and *E*, and the expansion seen in the blue showed a very faint line, more refrangible than *F*. The spectrum was not very bright, but was clearly defined.

The lines observed lost much of their brilliancy in the upper parts of the cone, and at  $30^{\circ}$  or  $40^{\circ}$  they became invisible, and the continuous spectrum only remained. These observations have been repeated on several occasions.

I resolved to ascertain the positions of these lines with the utmost accuracy that my limited means permit me, and disposed the induction coil and a set of Geissler's tubes.

The oxygen gas gives a spectrum of some lines, a yellow one being extremely conspicuous. Between this and the first of a green group, is situated the yellow line of the zodiacal light. If we adopt the Kirchhoff scale—and for the line *A* the number 405, for the *C* the 694, for the *D* the 1,004, and for the *E* the 1,523—I should suppose that the number corresponding to the yellow line is the 1,480, or a little less. This estimation, it is understood, is only an approximation.

The Hoffmann spectro-scope is a very good one for the more refrangible colours of the spectrum; the blue and violet are exceedingly pretty.

The position of the other line has been determined by means of a tube of coal gas. There is a group of four vaporous lines in its spectrum, and the blue line coincides with them; the number that I have assigned to it is the 2,270 of the same scale.

These observations we continued for several weeks, the Zodiacal Light being visible above the horizon of Cadiz until the middle of May, but the brilliant hues being no longer detected.

From these results, which (somewhat partially) I believe original, I think possible to infer the confirmation of the opinion of some astronomers, that the luminous atmosphere of the Sun is greater than that seen during the eclipses, its inferior part being the corona, and the limit reaching *Venus* and the Earth.

I would be very glad if some other observer, more competent than myself, would see if the lines that I have observed have any coincidence with any of the corona lines. It is possible that the line 1,480 might be the 1,474 of the *Aurora Borealis*.

Respecting the blue line, I am well convinced of its existence, but not so of its situation, nor whether it corresponds or not to the spectrum of carburetted hydrogen; but if this coincidence could be proved, remembering that the materials of comets must direct themselves to the Sun, as the great centre of attraction,

we cannot be surprised at the intimate connection which the spectroscope reveals to us between the physical nature of this star and the carbonous bodies that go to feed it.

It would lead me too far from my purpose to enter into a discussion of the before-mentioned phenomenon; others, with more right, can treat this matter with a knowledge that I do not possess.

*Observations of Coggia's Comet = Comet III, 1874, made at Dunsink Observatory, Dublin.*

| 1874    | Dublin M.T.<br>h m s |    |      | R.A.<br>h m s |    |       | Decl. "    | Remarks                          | Observer |
|---------|----------------------|----|------|---------------|----|-------|------------|----------------------------------|----------|
| June 11 | 13                   | 41 | 20.0 | 7             | 2  | 16.63 | +69 1 3.4  | Very unsteady.                   | Brünnow. |
| " 12    | 13                   | 39 | 10.8 | 7             | 4  | 3.62  | 68 59 55.3 |                                  | "        |
| " 13    | 13                   | 34 | 54.9 | 7             | 7  | 40.17 | 68 56 11.8 |                                  | "        |
| " 14    | 13                   | 32 | 47.8 | 7             | 9  | 29.30 | 68 53 25.0 |                                  | "        |
| " 15    | 13                   | 28 | 35.4 | 7             | 13 | 9.33  | 68 45 41.6 | Exceedingly bad }<br>atmosphere. | "        |
| " 16    | 13                   | 24 | 22.8 | 7             | 16 | 49.16 | 68 34 16.2 |                                  | "        |
| " 17    | 13                   | 11 | 21.8 | 7             | 27 | 25.35 | +67 26 8.5 |                                  | Ball.    |

*Dunsink, November 19, 1875.*

*Discovery and Observations of Eight Minor Planets (149) to (156).*

Planet (149) was discovered by M. Perrotin, at the observatory of Toulouse, on September 21, the R.A. and N.P.D. at 8<sup>h</sup> mean time of Toulouse, being respectively 23<sup>h</sup> 16<sup>m</sup> 8<sup>s</sup> and 95° 12'. Magnitude 13.

Planet (150) was discovered by Mr. Watson, at Ann Arbor. A telegram announcing its discovery was received in Europe on October 19. Magnitude 10.11. The following early observations have been made in Europe:

| 1875.   | h m s |    |    |                 | Observed R.A.<br>h m s | l.f.p. | Observed N.P.D.<br>° ' " | l.f.p. |
|---------|-------|----|----|-----------------|------------------------|--------|--------------------------|--------|
| Oct. 21 | 9     | 10 | 57 | M.T. Düsseldorf | 0 59 2.92              | ...    | 83 14 51.2               | ...    |
| 25      | 9     | 8  | 22 | " "             | 0 56 18.09             | ...    | 83 35 40.4               | ...    |
| 26      | 10    | 46 | 2  | " Pola          | 0 55 37.60             | 7.311  | 83 41 3.8                | 9.792  |
| 27      | 13    | 32 | 10 | " Leipzig       | 0 54 54.53             | 9.422  | 83 46 37.3               | 0.807  |
| Nov. 1  | 12    | 52 | 30 | " Berlin        | 0 52 0.73              | 9.378  | 84 9 38.0                | 0.818  |
| 2       | 9     | 18 | 25 | " "             | 0 51 33.87             | 8.863  | 84 13 16.4               | 0.810  |

Planet (151) was discovered by M. Palisa, at Pola, on November 1. Magnitude 12. The following are the first observations:

| 1875.  | h m s |    |    | Observed R.A.<br>h m s | l.f.p.    | Observed N.P.D.<br>° ' " |    |         | l.f.p. |
|--------|-------|----|----|------------------------|-----------|--------------------------|----|---------|--------|
|        |       |    |    |                        |           |                          |    |         |        |
| Nov. 1 | 13    | 24 | 25 | M.T. Pola              | 3 2 17.04 | 9.096                    | 71 | 39 34.9 | 0.604  |
| 2      | 10    | 37 | 26 | „ Berlin               | 3 1 23.69 | 9.196                    | 71 | 40 59.1 | 0.708  |

Planet (152) was discovered by M. Paul Henry, at Paris, on November 2. Magnitude 12. Its observed place at 11<sup>h</sup> 0<sup>m</sup> mean time of Paris was R.A. = 2<sup>h</sup> 38<sup>m</sup> 17<sup>s</sup>, and N.P.D. = 74° 35'. Motion small in polar distance.

Planet (153) was discovered by M. Palisa, at Pola, on November 2. Magnitude 12.5. Its observed place at 12<sup>h</sup> 40<sup>m</sup> mean time of Pola was R.A. = 3<sup>h</sup> 1<sup>m</sup> 28<sup>s</sup> and N.P.D. = 72° 25'.

Planet (154) was discovered by M. Prosper Henry, at Paris, on the evening of November 4. Magnitude 12. The following observations of R.A. and N.P.D. were approximate, owing to unfavourable weather:

|      |        |     | R.A. |    |    | N.P.D. |    |   |
|------|--------|-----|------|----|----|--------|----|---|
|      |        |     | h    | m  | s  | °      | '  | " |
| 1875 | Nov. 4 | 10  | 2    | 28 | 46 | 73     | 31 |   |
|      |        | 6 8 | 2    | 26 | 57 | 73     | 32 |   |

Planet (155) was discovered by M. Palisa, at Pola, on November 8, and was of the 12th magnitude. The following are the original observations:—

| 1875.  | Mean Time at Pola. |    |   | Observed R.A. |   |      | l.f.p. | Observed N.P.D. |    |      | l.f.p. |
|--------|--------------------|----|---|---------------|---|------|--------|-----------------|----|------|--------|
|        | h                  | m  | s | h             | m | s    |        | °               | '  | "    |        |
| Nov. 8 | 15                 | 21 | 9 | 3             | 0 | 9.51 | 9.552  | 70              | 52 | 15.3 | 0.668  |
|        | 16                 | 3  | 6 | 3             | 0 | 7.58 | 9.599  | 70              | 52 | 10.3 | 0.696  |

Planet (156) was discovered also by M. Palisa, at Pola, on November 22. The telegram gives its R.A. for November 23 as 2<sup>h</sup> 54<sup>m</sup>, and its N.P.D. 70° 30'. It had a southerly motion in declination, and its magnitude was the twelfth.

E. D.

Burlington House, London,

1875, November 25.

Corrections to Mr. De La Rue's "Auxiliary Tables for Determining the Position of the Sun's Axis, and the Latitude and Longitude of the Earth referred to the Sun's Equator."

|               |            |           |
|---------------|------------|-----------|
| ☉ 90° 50' for | diff. 4.71 | read 4.70 |
| 169 40 "      | 50.77      | " 50.27   |
| 50 "          | 52.69      | " 52.19   |

Page 1, last line:—For "Heliographical Longitude of the Earth," read "Longitude of the Earth referred to the Sun's Equator."